A Comparison of Estimates of First Nations Catches of Fraser River Sockeye Salmon from 1996 to 1999 by Scale-based Discriminant Function Models and Run Reconstruction Models

Jim Gable

December, 2002

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ABSTRACT

Historically, the Pacific Salmon Commission has used run reconstruction models to assign stock of origin to sockeye salmon (*Onchorhynchus nerka*) catches in the Fraser River First Nations fishery. Since 1987, scale samples have been collected from sockeye caught in the First Nations fishery to enable the Pacific Salmon Commission to make direct scale-based estimates of the catch by stock group. Scale parameters measured from the sockeye scales were used in linear discriminant function analyses (DFA) and the results of the analyses were applied to fishery catches to estimate the catch by stock group in the First Nations fishery. This report provides a comparison of catch by stock group in the Fraser River First Nations fishery from run reconstructions and DFA models for the years 1996 to 1999.

Estimates from the scale-based DFA and the run reconstruction models were generally similar. However, in several cases catch estimates by stock group within years differed substantially (sometimes > 50%) between the two estimators. These differences in catch estimates between DFA and run reconstruction were likely attributable to: i) adverse sockeye migration conditions in the Fraser River in some years (i.e. high discharge and high water temperatures) that affected the relative vulnerability of individual sockeye stocks to First Nations fisheries,and ii) the inability of run reconstruction models to adjust catch estimates for these effects. The scale samples collected for the DFA analyses provided direct measures of the stock groups present in in-river fishery catches, consequently, this technique was sensitive to differences in stock vulnerability to fisheries attributable to the unusual migratory conditions. Scale-based DFA models should provide more accurate estimates of catch by stock group in the Fraser River First Nations fishery because of their ability to assess the variability in sockeye timing within and between years. Consequently, this technique is considered preferable to run reconstruction.

Recommendations for improving the scale-based DFA approach include more thorough (increasing sample sizes and numbers of collections at designated sites) and consistent (better spatial and temporal coverage across years) sampling of First Nations catches of sockeye salmon in the Fraser River. Additionally, the number of sampling locations in the Fraser River should likely be increased to more accurately estimate catches by stock group as a result of the generally larger catch allocations of Fraser River sockeye to First Nations fisheries.

INTRODUCTION

Historically, First Nations catches of Fraser River sockeye salmon that occur in the Fraser River watershed have been apportioned into stock components using run reconstruction models that incorporate the hydroacoustic estimates of daily escapement passing Mission, B.C., for individual stock groups (Gable 1998). Key assumptions in this model are: (1) the upstream migration speed of sockeye stocks are estimated accurately; (2) the sockeye stocks are equally available and vulnerable to fisheries occurring upstream of Mission; and (3) the individual daily stock profiles generated at Mission are accurate. The last assumption is contingent upon the Pacific Salmon Commission's (PSC) in-river test fisheries being non-selective in their daily sampling of sockeye stocks migrating past Mission, and accurate hydroacoustic estimates of daily sockeye abundances.

Run reconstruction methodology was considered an adequate method to apportion the Fraser River First Nations sockeye catch into stock groups in the 1960's and 1970's. During this period the annual catches of sockeye were generally 100,000 to 200,000 fish (Macdonald 1992). Increased catch allocation to the First Nations fisheries in the 1980's resulted in the average annual catch increasing to over 400,000 sockeye from 1980 to 1989 (Macdonald 1992). This increase in catch caused the PSC to implement, with the assistance of DFO and First Nations, a more direct, scale-based method of estimating the individual stock group contributions in the sockeye salmon fishery.

Programs to collect scale samples from sockeye caught in First Nations fisheries in the Fraser River have been conducted since 1987. Similar scale sampling programs are conducted by the PSC on commercial and test fishery catches, to provide estimates of sockeye catch by stock group in these fisheries. The PSC applies scale pattern analysis to identify sockeye stock groups in these mixed stock fishery samples. Linear discriminant function analysis (DFA) is the statistical method used to apportion the catches into unique stock groups (Gable and Cox-Rogers 1993).

An advantage of using scale samples to directly estimate catch by stock group in First Nations fisheries in the Fraser River, as opposed to using run reconstruction, is that the scale-based assessment method does not depend on assumptions regarding the availability of the sockeye stocks. This is particularly important in years that the normal migratory behavior of sockeye is disrupted due to high water temperatures or difficult upstream passage conditions. The key assumption of the scale-based approach is that the scale samples are obtained randomly so that the sampled fraction is representative of the entire catch. This approach also requires that sampled scales are obtained from the "preferred area" of individual fish and that the time and location of the sampled catches are accurately recorded to ensure that estimates of stock proportions are applied appropriately.

The estimates of catch by stock group generated by run reconstruction and scale-based DFA models were compared for the period 1989 to 1995 (Gable 1998). In general, the DFA and run reconstruction estimates provided consistent estimates of sockeye catch by stock group. The scale-based DFA methodology was considered preferable because the estimates were derived directly from sockeye caught in First Nations fisheries, and therefore were more sensitive to identifying stock group contributions at specific catch sites in the river. In addition, the sampling assumptions in the First Nations scale estimation program could be controlled through adequate sampling design and implementation. Conversely, assumptions in the run reconstruction model regarding migration speed, and availability and vulnerability of stock groups to harvest, were highly susceptible to violation. Disruptions in the migration of sockeye salmon were observed in both 1997 and 1999 when unusually high Fraser River discharges affected the upstream passage

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of Early Stuart and Early Summer sockeye, and to a lesser extent the migration of later-timed stock groups. These events provided additional impetus to continue refinement of the scale-based DFA approach to estimating catches of Fraser River sockeye by stock group in First Nations fisheries.

The main objectives of this report are to: (1) document the scale samples that were collected by First Nations samplers from 1996 to 1999, and to tabulate the corresponding catches; (2) compare scale-based DFA estimates and run reconstruction estimates of catch by stock group for the same period; (3) generate "best" estimates of sockeye catch by stock group; and (4) recommend improvements to the scale sampling program.

METHODS

Sample Collections

The First Nations scale-sampling program was initiated in 1987. The primary goal of the program was to sample sockeye salmon at the several important catch locations in areas upstream of the PSC's hydroacoustic monitoring site at Mission so that accurate estimates of catch by stock group could be generated. It was assumed that the analysis of sockeye scale samples taken from the two PSC test fisheries that are conducted downstream of Mission provide accurate estimates of catch by stock group in fisheries occurring in this area.

The PSC annually requests that Fisheries and Oceans Canada (DFO), in conjunction with First Nations representatives, collect weekly scale samples from approximately 240 sockeye from specified sites along the main stem of the Fraser River. Catch areas where scale samples were obtained during the study period (1996 to 1999) included: Mission to Hope (Chilliwack), Hope to Sawmill Creek (Yale), Sawmill Creek to Lytton (Lytton East), Lytton to Lillooet (Lytton West), Lillooet to Kelly Creek (Bridge River), and Deadman Creek to Marguerite (Sheep Creek) (Figure 1). The request for samples includes a designated sampling site on the Fraser River downstream of Prince George near Stoner Creek. However, too few scales were typically obtained from this area to generate reliable stock composition estimates.

From 1996 to 1999, 87 scale samples were collected where the sample size exceeded 50 scales, for a total of 15,212 scales. The sampling locations, dates and sample sizes that were obtained during this period are summarized in Table 1. The goal of obtaining adequate weekly samples from each designated sampling site was not achieved in many weeks and areas, particularly in 1996 and 1999. However, the sampling program was more successful in both 1997 and 1998.

In 1996, scale samples were obtained from five sites, but at three of the sites (Chilliwack: 116 scales, Lytton East: 69 scales, and Lytton West: 76 scales) only one sample was obtained (Table 1). At the Yale sampling site two samples (502 scales) were taken, and at the Bridge River site four samples (1,137 scales) were obtained.

In both 1997 and 1998, more comprehensive sets of samples were obtained from a total of six sites, over a four to nine week period. At both Chilliwack and Yale, samples were obtained from four weeks of fishing in 1997 (329 scales at Chilliwack and 759 scales at Yale) and from five weeks in 1998 (949 scales at Chilliwack and 1,118 scales at Yale). At Lytton East the sampling covered six weeks in 1997 (576 scales) and seven weeks in 1998 (915 scales). At Lytton West, eight weeks of fishing were sampled in 1997 (831 scales), while in 1998 samples were obtained from four weeks of fishing (404 scales). The sampling at Bridge River spanned
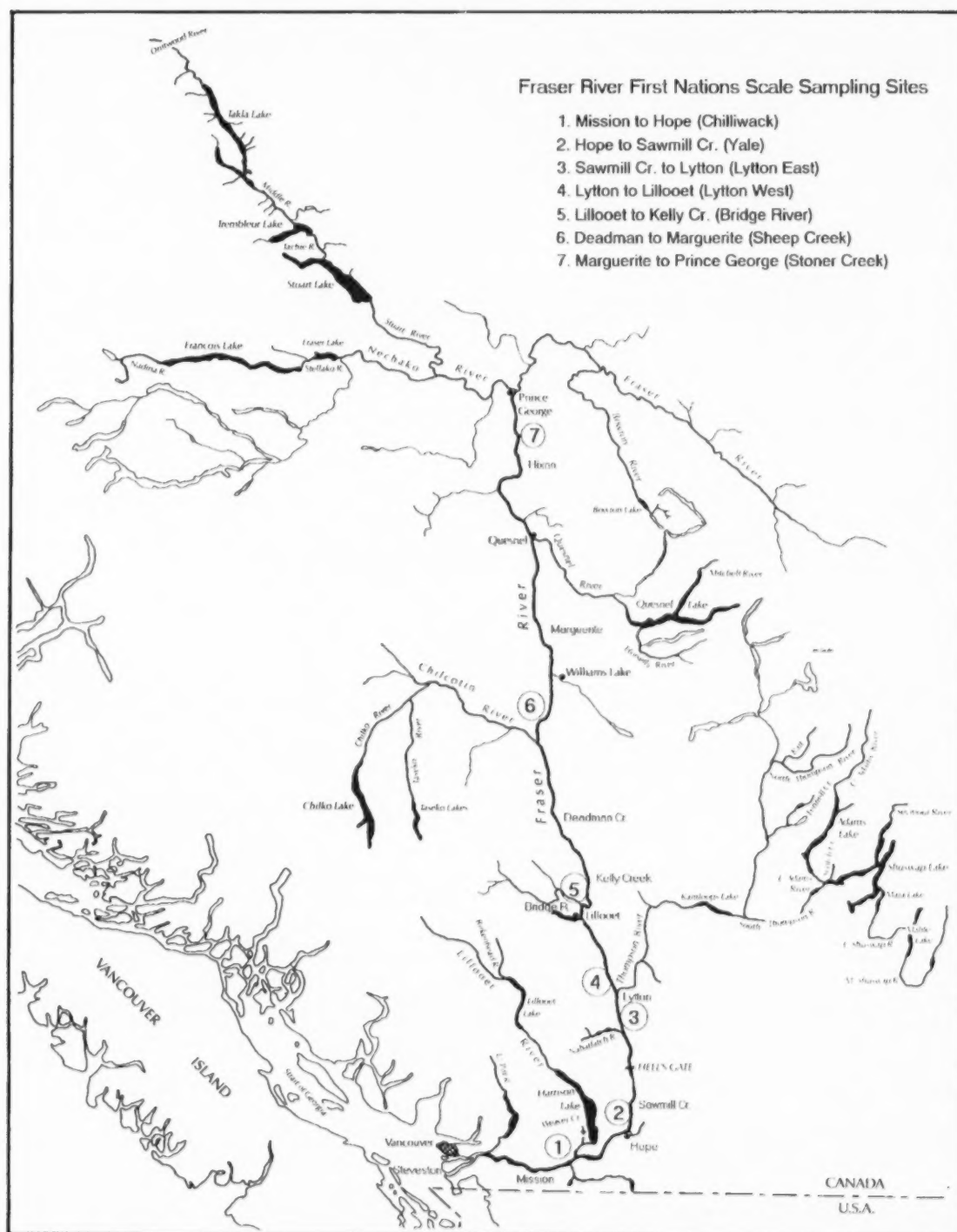
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Figure 1. First Nations scale sampling sites in the Fraser River watershed.

Table 1. Scale samples from sockeye salmon caught in First Nations fisheries from 1996 to 1999.

Year	Sampling Location	Sample Dates	Number of Scales
1996	Chilliwack	Aug 12-13	116
		Annual Total:	116
1996	Yale	Aug 3-4	222
	Yale	Aug 10-15	280
		Annual Total:	502
1996	Lytton East	Aug 8-11	69
		Annual Total:	69
1996	Lytton West	Aug 7-11	76
		Annual Total:	76
1996	Bridge River	Aug 4-10	327
	Bridge River	Aug 11-17	398
	Bridge River	Aug 18-24	331
	Bridge River	Aug 27-28	81
		Annual Total:	1,137
Total Scale's Sampled (1996):			**1,900**

Year	Sampling Location	Sample Dates	Number of Scales
1997	Chilliwack	Jul 8-9	140
	Chilliwack	Jul 23-24	84
	Chilliwack	Aug 14-16	52
	Chilliwack	Aug 20-22	53
		Annual Total:	329
1997	Yale	Aug 14-16	209
	Yale	Aug 20-22	212
	Yale	Aug 29-30	134
	Yale	Sep 1-2	204
		Annual Total:	759
1997	Lytton East	Jul 16-20	88
	Lytton East	Jul 23-27	175
	Lytton East	Aug 6-10	108
	Lytton East	Aug 12-15	65
	Lytton East	Aug 28-29	54
	Lytton East	Sep 10-14	86
		Annual Total:	576
1997	Lytton West	Jul 10-13	72
	Lytton West	Jul 17-20	146
	Lytton West	Jul 23-26	109
	Lytton West	Jul 28-30	91
	Lytton West	Aug 7-10	67
	Lytton West	Aug 11-17	61
	Lytton West	Aug 18-24	83
	Lytton West	Aug 25-31	202
		Annual Total:	831
1997	Bridge River	Jul 10-13	187
	Bridge River	Jul 17-20	118
	Bridge River	Jul 23-27	273
	Bridge River	Jul 28-Aug 3	229
	Bridge River	Aug 4-10	251
	Bridge River	Aug 11-17	217
	Bridge River	Aug 18-24	201
	Bridge River	Aug 25-31	234
	Bridge River	Sep 1-7	137
		Annual Total:	1,847
1997	Sheep Creek	Jul 21-27	312
	Sheep Creek	Jul 28-Aug 3	481
	Sheep Creek	Aug 4-10	153
	Sheep Creek	Aug 11-16	148
	Sheep Creek	Aug 19-24	123
	Sheep Creek	Aug 25-31	77
		Annual Total:	1,294
Total Scale's Sampled (1997):			**5,636**

Year	Sampling Location	Sample Dates	Number of Scales
1998	Chilliwack	Jul 29-Aug 1	135
	Chilliwack	Aug 6-7	187
	Chilliwack	Aug 12-15	267
	Chilliwack	Aug 18-22	179
	Chilliwack	Aug 25-28	181
		Annual Total:	949
1998	Yale	Jul 29-Aug 1	249
	Yale	Aug 4-7	209
	Yale	Aug 12-15	211
	Yale	Aug 18-22	213
	Yale	Aug 25-28	236
		Annual Total:	1,118
1998	Lytton East	Aug 1-2	86
	Lytton East	Aug 5-7	106
	Lytton East	Aug 11-16	69
	Lytton East	Aug 17-21	103
	Lytton East	Aug 24-30	141
	Lytton East	Aug 31-Sep 5	219
	Lytton East	Sep 7-10	191
		Annual Total:	915
1998	Lytton West	Jul 31-Aug 2	56
	Lytton West	Aug 5-9	75
	Lytton West	Aug 10-16	186
	Lytton West	Aug 17-21	87
		Annual Total:	404
1998	Bridge River	Jul 27-Aug 2	514
	Bridge River	Aug 3-9	798
	Bridge River	Aug 10-16	406
	Bridge River	Aug 17-23	253
	Bridge River	Aug 24-30	200
	Bridge River	Aug 31-Sep 6	56
	Bridge River	Sep 7-13	76
		Annual Total:	2,363
1998	Sheep Creek	Jul 27-Aug 2	144
	Sheep Creek	Aug 3-9	216
	Sheep Creek	Aug 10-16	100
	Sheep Creek	Aug 17-23	52
	Sheep Creek	Aug 24-30	50
		Annual Total:	562
Total Scale's Sampled (1998):			**6,251**

Year	Sampling Location	Sample Dates	Number of Scales
1999	Chilliwack	Aug 7-8	65
		Annual Total:	65
1999	Yale	Jul 26-31	280
	Yale	Aug 5-7	220
	Yale	Aug 8-10	97
		Annual Total:	597
1999	Bridge River	Aug 3-9	188
	Bridge River	Aug 10-16	222
	Bridge River	Aug 18-22	297
		Annual Total:	707
1999	Sheep Creek	Aug 5-6	56
		Annual Total:	56
Total Scale's Sampled (1999):			**1,425**

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nine weeks in 1997 (1,847 scales) and seven weeks in 1998 (2,303 scales). At Sheep Creek the sampling covered six weeks in 1997 (1,294 scales) and five weeks in 1998 (562 scales).

The sampling coverage was less successful in 1999 when scale samples were obtained from only four designated sampling sites. At Chilliwack one sample was obtained (65 scales), while three samples were obtained at both Yale and Bridge River for a total of 597 and 707 scales, respectively. One sample (56 scales) was also obtained at Sheep Creek.

Data Analysis

The PSC's approach to the application of a scale-based methodology in the apportioning of mixed stock fishery catches into individual stock groups, including the development of spawning ground standards and the selection of scale variables, is summarized in Gable (1998) and Gable and Cox-Rogers (1993). The technique used is termed scale pattern analysis, and involves the comparison of stock-specific variations in the widths and numbers of circuli in the freshwater growth zone of scales. Baseline standards are collected annually from natal spawning streams. Once analyzed, the standards allow scale samples obtained from mixed stock fisheries such as those conducted by Fraser River First Nations, to be separated into discrete stock groups.

Sample size is important in stock identification analyses because the precision of stock composition estimates decreases as the mixture sample size is reduced. The PSC has a minimum target level of 120 scales for assessing sockeye stock contributions in mixed-stock fishery catches. However, this target level was often not achieved in the sampling of specific First Nations catches in the Fraser River. To increase the number of weeks and areas where scale-based data could be used, the minimum criterion of 120 scales was decreased to 50 scales per sample. The precision of the individual estimates is reduced using this lower sample size criterion (Gable and Cox-Rogers 1993), and in addition, some reduction in the accuracy of the stock composition estimates may result.

A second important point in the analyses was that stock groups expected in small proportions (less than 5%) in the mixture samples were not included in the scale analyses, but were assigned percentages using a tailing methodology (Gable and Cox-Rogers 1993). This technique minimizes the overestimation of stocks that are present in small proportions, which is a bias common in multivariate analyses, such as DFA, and is a potential source of bias with both the run reconstruction and scale-based assessment methods evaluated in this paper.

RESULTS

The application of the scale data to catches in each sampling region was reviewed and the coverage in each sampling area was assessed. Estimates of catch by stock group derived from run reconstruction and scale analyses were compared across fishing areas. Finally, "best estimates" of catch by stock group were developed that utilized scale data, in conjunction with run reconstruction data (when scale data were unavailable and when the minimum sample size criteria for scale samples was not achieved).

1996 Results

Application of Scale Data to Catches in First Nations Fisheries

The scale-sampling program did not achieve the desired sampling coverage or sample sizes in 1996. In the Mission to Hope catch area, only one sample was obtained at Chilliwack, on

August 12-13 (Appendix Table 1). The corresponding catch on these days was 16,556 fish, and the stock composition was estimated from the scale data. The catch represented 21.5% of the season total catch of 77,177 fish (Table 2). Catches taken outside of the sample dates were apportioned into stock groups using the run reconstruction model.

In the Hope to Sawmill Creek catch region, two scale samples were obtained at Yale during the August 3-4 and the August 10-15 fishery periods (Appendix Table 1). Stock composition estimates from these samples were derived using the scale-based DFA models. The stock composition for the intervening period (August 5-9) was estimated by interpolating the results from the August 3-4 and August 10-15 samples. In total, the catch for the period from August 3 to August 15 was 135,921 fish, with the majority of the catch (123,946 fish) occurring from August 10-15. The catch of 135,921 sockeye was 62.0% of the season catch total of 219,355 fish harvested in the area (Table 2). Stock proportions were assigned to catches taken before August 3 and after August 15 using the run reconstruction model.

In the catch area from Sawmill Creek to Lytton one sample was obtained between August 8-11 (Appendix Table 1). To increase the application of scale-based results, stock proportions estimated from DFA models in the Hope to Sawmill Creek area were extrapolated to the Sawmill Creek to Lytton area, using a two-day time lag. This expanded the coverage to August 5-6 and August 12-17. The DFA stock composition estimates for the period August 5-17 were applied to catches totaling 38,917 sockeye. The catch of 38,917 fish was 37.2% of the season total catch of 104,626 sockeye harvested in the area (Table 2). The remaining catch of 65,709 fish was apportioned into stock groups using the run reconstruction model.

One scale sample was obtained in the area from Lytton to Lillooet between August 7-11 (Appendix Table 1). Estimates were extrapolated from lower catch areas, with adjustments to compensate for the absence of stocks migrating up the Thompson River. This expanded the scale-based coverage to the period from August 12 to August 19. The catch harvested during the period from August 7 to August 19 totaled 11,000 sockeye, which was 56.7% of the total catch of 19,407 sockeye harvested in the area (Table 2). Catches taken before August 7 and after August 19 were assigned stock compositions using the run reconstruction model.

More complete scale sampling coverage was achieved in the First Nations fishery occurring from Lillooet to Kelly Creek (i.e., near Bridge River). Scale samples were collected from the following periods: August 4-10, August 7-11, August 18-24 and August 27-28 (Appendix Table 1). The stock composition for August 25-26 was estimated by interpolating the results from the August 18-24 and August 27-28 samples. Scale-based stock composition estimates were produced for the period from August 4-28. The harvest during this period was 17,775 fish, which represented 91.6% of the total catch for the area of 19,408 fish (Table 2). The catch that was harvested outside of this period was estimated using the run reconstruction model.

In total, nine scale samples were obtained from five sampling sites spanning from Chilliwack to Bridge River. Scale samples were not obtained from sampling areas between Kelly Creek and Prince George. The application of scale-based DFA results to First Nations catches occurring within the catch regions was expanded by interpolating samples within areas, and by extrapolating samples to adjacent areas. The expanded scale-based stock compositions were applied to catches totaling 220,169 fish or 49.3% of the 446,942 sockeye harvested in the Fraser River between Mission and Marguerite (Table 2).

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Table 2. Proportion of catch estimated from scales in 1996.

Catch Area	Proportion Of Catch Represented By Scale Samples (Targeted Catch Areas Only)		
	Scale-based Catch [1]	Total Catch	% of Scale-based to Total Catch
Mission to Hope	16,556	77,177	21.5%
Hope to Sawmill Creek	135,921	219,355	62.0%
Sawmill Creek to Lytton	38,917	104,626	37.2%
Lytton to Lillooet	11,000	19,407	56.7%
Lillooet to Kelly Creek	17,775	19,408	91.6%
Deadman to Marguerite	0	6,969	0.0%
Total	220,169	446,942	49.3%

1. The catch represented by scale samples includes the estimated catch of minor stocks (present in
expected proportions of less than 5%). The minor stocks were estimated using a tailing methodology.

Comparison of DFA and Run Reconstruction Catch Estimates

In 1996, stock groups estimated entirely from run reconstruction models included Early
Stuart, Birkenhead, Weaver/Portage and Adams/Lower Shuswap. Consequently, no comparison
between run reconstruction and scale-based results are available for these stock groups. Stock
proportions estimated from DFA models were available for the Early Summer (comprised of
several small stocks, including Fennell, Bowron, Scotch and Seymour), Nadina/Gates/Pitt,
Chilko/Quesnel and Late Stuart/Stellako stock groups. Catches by stock group and by catch area
for the run reconstruction and the scale-based estimates are presented in Table 3.

Sockeye catch estimates for the Early Summer stock group incorporated scale-based
DFA model estimates from both the Hope to Sawmill Creek and the Sawmill Creek to Lytton
areas. In other catch areas where scale data had been collected, the expected stock proportions
for the Early Summer stock group were less than 5%. Consequently, the stock proportions were
estimated using the run reconstruction model. In both areas where scale data were used, the
scale-based Early Summer estimate exceeded the run reconstruction estimate. In the Hope to
Sawmill Creek area the scale-based estimate was 15,193 sockeye. This estimate was 10,726 fish
(70.6%) higher than the catch estimate of 4,467 fish generated using the run reconstruction model
(Table 3). In the Sawmill Creek to Lytton area the scale-based estimate of First Nations catch for
the stock group was 4,056 sockeye, or 1,539 fish (37.9%) higher than the estimate of 2,517 fish
produced by the run reconstruction model.

The Nadina/Gates stock group was estimated with at least one week of scale-based data
in the Hope to Sawmill Creek, Sawmill Creek to Lytton and the Lytton to Lillooet areas. In the
Hope to Sawmill Creek and Lytton to Lillooet areas, the scale-based catch estimates were lower
for the Nadina/Gates stock group than estimates derived using the run reconstruction model. In
the Hope to Sawmill Creek area the scale-based estimate of 7,448 fish was 6,564 fish (88.1%)
lower than the run reconstruction estimate of 14,012 fish (Table 3). In the Lytton to Lillooet area
the scale-based estimate of 1,124 sockeye was 519 fish (46.2%) lower than the run reconstruction
estimate of 1,643 fish. In the Sawmill Creek to Lytton area the two estimates of Nadina/Gates
catch were within 158 fish (2.0%), with a scale-based estimate of 7,764 sockeye and a run
reconstruction estimate of 7,606 sockeye.

The two Summer-run stock groups were estimated with at least one week of scale data in
each of the five areas where scale samples were collected. Unlike the early-timed stock groups,

Table 3. Catch by stock group comparisons in 1996 (in regions and during times where the scale program was implemented).

Stock Group	Catch by Stock Group: Reconstruction Model[1]						
	Mission to Hope	Hope to Sawmill Cr.	Sawmill Cr. to Lytton	Lytton to Lillooet	Lillooet to Kelly Cr.	Deadman to Marguerite	Total
Early Stuart							
Early Summers (Misc. stocks)		4,467	2,517				6,984
Nadina, Gates, Pitt		14,012	7,606	1,643			23,261
Chilko, Quesnel	7,715	61,429	15,852	5,038	9,560		99,594
Late Stuart, Stellako	7,019	55,910	12,935	4,291	7,517		87,672
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson							
Total	14,734	135,818	38,910	10,972	17,077	0	217,511

Stock Group	Catch by Stock Group: Scale Data[1]						
	Mission to Hope	Hope to Sawmill Cr.	Sawmill Cr. to Lytton	Lytton to Lillooet	Lillooet to Kelly Cr.	Deadman to Marguerite	Total
Early Stuart							
Early Summers (Misc. stocks)		15,193	4,056				19,249
Nadina, Gates, Pitt		7,448	7,764	1,124			16,336
Chilko, Quesnel	10,615	60,972	13,783	5,541	13,289		104,200
Late Stuart, Stellako	4,119	52,205	13,306	4,282	3,973		77,885
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson							
Total	14,734	135,818	38,909	10,947	17,262	0	217,670

Stock Group	Differences in Catch by Stock Group: (Scale Data - Reconstruction Model)						
	Mission to Hope	Hope to Sawmill Cr.	Sawmill Cr. to Lytton	Lytton to Lillooet	Lillooet to Kelly Cr.	Deadman to Marguerite	Total
Early Stuart							
Early Summers (Misc. stocks)		10,726	1,539				12,265
Nadina, Gates, Pitt		-6,564	158	-519			-6,925
Chilko, Quesnel	2,900	-457	-2,069	503	3,729		4,606
Late Stuart, Stellako	-2,900	-3,705	371	-9	-3,544		-9,787
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson							
	Differences in Catch by Stock Group (%): ((S.D.-R.M.)/S.D.)						
Early Stuart							
Early Summers (Misc. stocks)		70.6%	37.9%				63.7%
Nadina, Gates, Pitt		-88.1%	2.0%	-46.2%			-42.4%
Chilko, Quesnel	27.3%	-0.7%	-15.0%	9.1%	28.1%		4.4%
Late Stuart, Stellako	-70.4%	-7.1%	2.8%	-0.2%	-89.2%		-12.6%
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson							

1. The estimated catch does not include minor stocks (present in expected proportions of less that 5%) which were estimated indirectly.

no strong directional trends were identified when the scale-based estimates of catch were compared to the run reconstruction estimates.

The scale-based estimate of catch for the Chilko/Quesnel stock group was higher than the run reconstruction estimate in three areas (Mission to Hope, Lytton to Lillooet and Lillooet to Kelly Creek), and was lower in two areas (Hope to Sawmill Creek and Sawmill Creek to Lytton). The numerical differences were highest in the Lillooet to Kelly Creek area, where the scale-based estimate exceeded the run reconstruction estimate by 3,729 fish (28.1%). In the other four areas the estimates were similar. The largest positive difference was 2,900 fish (27.3%) in the Mission

to Hope area; while the largest negative difference was 2,069 fish (15.0%) in the Sawmill Creek to Lytton area (Table 3).

The scale-based estimate of catch for the Late Stuart/Stellako stock group was lower than the run reconstruction model in four areas (Mission to Hope, Hope to Sawmill Creek, Lytton to Lillooet and Lillooet to Kelly Creek) and higher in one area (Sawmill Creek to Lytton) (Table 3). The largest percentage difference between the two estimates was in the Lillooet to Kelly Creek area where the discrepancy was negative (3,544 fish, 89.2%). Differences in the estimates of catch in the other four areas were small. The largest negative discrepancy was 3,705 fish (7.1%) in the Hope to Sawmill Creek area; the only positive discrepancy (371 fish, 2.8%) was in the Sawmill Creek to Lytton area.

Best Estimates of Catch By Stock Group (All Areas)

The total catch of sockeye in the Fraser River First Nations fishery in 1996 was 677,532 fish. Catches in the four regions of the watershed are summarized in Table 4: Steveston to Mission (164,773 fish), Mission to Sawmill Creek (296,532 fish), Sawmill Creek to Prince George (151,243 fish) and terminal catch areas (Thompson, Chilcotin, Nechako and Stuart Rivers, 64,984 fish). The best estimate of catch by stock group was calculated using DFA models for areas and weeks where scale samples were collected, and by run reconstruction for areas and weeks where scale samples were not available. Interpolation of scale data within catch areas, and extrapolation of scale data between catch areas, were used to increase the coverage of the scale data.

Scale data from First Nations fishery catches were available to assess catch by stock group for a component of the catch in two of the four regions: Mission to Sawmill Creek and Sawmill Creek to Prince George. However, because of the limitations in applying scale-based estimates to minor stock groups, only a subset of stock groups were estimated using the DFA model. Minor stock groups, where the expected contribution was less than 5% in a given fishery, were not included in DFA models but were estimated using the run reconstruction model. In the Steveston to Mission and terminal areas, scale data from catches were not available. However, in the Steveston to Mission area, the daily sampling of sockeye caught in gillnet test fisheries should provide a close approximation of the stock composition in First Nations fisheries. In terminal areas, where run reconstruction models were used to apportion the catch into stock groups, generally only one or two stock complexes are present, thereby simplifying the estimation problem.

The best estimates of catch for the Early Stuart (2,576 fish), Birkenhead (3,956 fish), Weaver/Portage (4,996 fish) and Adams/Lower Shuswap (4,552 fish) stock groups were all relatively minor, with each comprising less than one percent of the total catch (Table 4). Contributions to these stock groups were estimated using the run reconstruction model.

The percentage differences between the best estimates and reconstruction estimates of catch for the miscellaneous Early Summer and Nadina/Gates stock groups were quite large. The best estimate of catch for the miscellaneous Early Summer stock group was 34,987 fish. This estimate was 12,234 fish (35.0%) higher than the run reconstruction estimate. In contrast, the best estimate for the Nadina/Gates stock group was 67,157 fish, which was 7,063 fish lower (10.5%) than the run reconstruction estimate (Table 4).

There were small differences between the best estimates and run reconstruction estimates for the Summer-run stock groups. The best estimate for the Chilko/Quesnel stock group was 344,960 fish, which was only 4,643 fish (1.3%) larger than the run reconstruction estimate. The

Table 4. Catch by stock group comparisons in 1996.

	Catch by Stock Group: Reconstruction Model				
Stock Group	Steveston to Mission	Mission to Sawmill Cr.	Sawmill Cr. to Prince George	Terminal Area Catches 1	Total Catch
Early Stuart	10	51	1,217	1,298	2,576
Early Summers (Misc. stocks)	5,751	9,818	6,908	276	22,753
Nadina, Gates, Pitt	15,847	30,447	25,978	1,948	74,220
Chilko, Quesnel	80,644	142,551	65,040	52,082	340,317
Late Stuart, Stellako	55,557	112,629	46,752	9,232	224,170
Birkenhead	3,956	0	0	0	3,956
Weaver, Portage & Misc. Late Runs	2,186	54	2,756	0	4,996
Adams & Misc. Late S. Thompson	822	982	2,592	148	4,544
Total	164,773	296,532	151,243	64,984	677,532

1. Terminal Areas include the Thompson River, Chilcotin River, Nechako River and Stuart River.

	Catch by Stock Group: Scale Data and Reconstruction Model (Best Estimates)				
Stock Group	Steveston to Mission	Mission to Sawmill Cr.	Sawmill Cr. to Prince George	Terminal Area Catches 1	Total Catch
Early Stuart	10	51	1,217	1,298	2,576
Early Summers (Misc. stocks)	5,751	20,541	8,424	271	34,987
Nadina, Gates, Pitt	15,847	23,875	25,473	1,962	67,157
Chilko, Quesnel	80,644	145,015	67,217	52,084	344,960
Late Stuart, Stellako	55,557	106,012	43,563	9,216	214,348
Birkenhead	3,956	0	0	0	3,956
Weaver, Portage & Misc. Late Runs	2,186	54	2,756	0	4,996
Adams & Misc. Late S. Thompson	822	984	2,593	153	4,552
Total	164,773	296,532	151,243	64,984	677,532

1. Terminal Areas include the Thompson River, Chilcotin River, Nechako River and Stuart River.

	Differences (Best Estimates minus Run Reconstruction Model Estimates)				
Stock Group	Steveston to Mission	Mission to Sawmill Cr.	Sawmill Cr. to Prince George	Terminal Area Catches 1	% Difference
Early Stuart					
Early Summers (Misc. stocks)		10,723	1,516		35.0%
Nadina, Gates, Pitt		-6,572	-505		-10.5%
Chilko, Quesnel		2,464	2,177		1.3%
Late Stuart, Stellako		-6,617	-3,189		-4.6%
Birkenhead					
Weaver, Portage & Misc. Late Runs					
Adams & Misc. Late S. Thompson					

1. Terminal Areas include the Thompson River, Chilcotin River, Nechako River and Stuart River.

best estimate for the Late Stuart/Stellako stock group was 214,348 fish, which was 9,822 fish (4.6%) lower than the run reconstruction estimate (Table 4).

1997 Results

Application of Scale Data to Catches in First Nations Fisheries

In 1997, scale samples were obtained at all designated sampling sites in the First Nations fishery, except for the Stoner Creek site. In the Mission to Hope catch area, samples were obtained from July 8-9, July 23-24, August 14-16 and on August 20-22 (Appendix Table 2). Estimates of the contribution by stock group were derived from scale-based DFA models for those catch periods. The catch from August 8-9 was estimated by interpolating between the July 23-24 and August 14-16 sample results. The catch for the period spanning from July 8 to August 22 was 91,152 fish, which was 87.7% of the season catch total of 103,959 sockeye from the

Mission to Hope area (Table 5). Catches taken before July 8 and after August 22 were assigned stock proportions from the run reconstruction model.

In the catch area from Hope to Sawmill Creek scale samples were collected during the following periods: August 14-16, August 20-22, August 29-30 and September 1-2 (Appendix Table 2). Stock proportions estimated from DFA models in the Mission to Hope area were extrapolated to the Hope to Sawmill Creek area for August 8-9 to expand the scale based coverage into early August. The DFA stock composition estimates for the period from August 8 to September 2 were applied to catches totaling 124,945 fish, which represented 41.7% of the total harvest of 299,725 fish for the area (Table 5). The remaining catch of 174,780 sockeye was apportioned into stock groups using the run reconstruction model.

In the Sawmill Creek to Lytton area six scale samples were obtained: July 16-20, July 23-27, August 6-10, August 12-15, August 28-29 and September 10-14. Catch estimates for August 11 were interpolated from the August 6-10 and August 12-15 samples, and for August 16-27 they were interpolated from the August 12-15 and August 28-29 samples (Appendix Table 2). In total, scale-based stock composition estimates were produced for the period from July 16 to September 14. The harvest during that period was 95,238 fish, or 74.3% of the total catch for the area (Table 5). Catches taken outside of this period (32,912 fish) were assigned stock proportions using the run reconstruction model.

Scale samplers in the Lytton to Lillooet and Lillooet to Kelly Creek areas provided thorough coverage of the sockeye catches. Samples were collected from the Lytton to Lillooet area during the following periods: July 10-13, July 17-20, July 23-26, July 28-30, August 7-10, August 11-17, August 18-24 and August 25-31. Scale samples obtained from the Lillooet to Kelly Creek area provided coverage of catches from July 10 to September 7. Individual samples were obtained from the following dates: July 10-13, July 17-20, July 23-27, July 28-August 3, August 4-10, August 11-17, August 18-24, August 25-31 and September 1-7 (Appendix Table 2).

In the Lytton to Lillooet area the harvest during the period covered by the scale samples was 28,968 fish, which was 94.7% of the total catch (30,599 fish) in the area (Table 5). The catch represented by scale samples obtained in the Lillooet to Kelly Creek area was 30,472 fish, or 99.6% of the total harvest of 30,598 sockeye (Table 5). The small catch in these areas not covered by scale-based estimates was apportioned into stock groups using the run reconstruction model.

In the Deadman Creek to Marguerite catch area six scale samples were obtained. Stock composition estimates from DFA models were generated from samples collected on the following dates: July 21-27, July 28-August 3, August 4-10, August 11-16, August 19-24 and August 25-31 (Appendix Table 2). The harvest during the period from July 21-August 31 was 49,646 fish, which represented 93.4% of the total catch for the area of 53,159 fish (Table 5).

In contrast to 1996 when only nine samples were obtained from four sampling sites, in 1997, 37 samples were collected from six sampling sites (Table 1). While some interpolation of samples within areas was performed, most of the scale-based stock composition estimates were generated from scale samples obtained at the sampling sites. The catch represented by the scale samples collected from First Nations, including interpolations, was 420,421 fish, or 65.1% of the 646,190 fish harvested in the Fraser River between Mission and Marguerite (Table 5).

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Table 5. Proportion of catch estimated from scales in 1997.

Catch Area	Proportion Of Catch Represented By Scale Samples (Targeted Catch Areas Only)		
	Scale-based Catch [1]	Total Catch	% of Scale-based to Total Catch
Mission to Hope	91,152	103,959	87.7%
Hope to Sawmill Creek	124,945	299,725	41.7%
Sawmill Creek to Lytton	95,238	128,150	74.3%
Lytton to Lillooet	28,968	30,599	94.7%
Lillooet to Kelly Creek	30,472	30,598	99.6%
Deadman to Marguerite	49,646	53,159	93.4%
Total	420,421	646,190	65.1%

1. The catch represented by scale samples includes the estimated catch of minor stocks (present in expected proportions of less than 5%). The minor stocks were estimated using a tailing methodology.

Comparison of DFA and Run Reconstruction Catch Estimates

In 1997, unusual migration behaviour was observed in many Fraser River sockeye stocks. Early Stuart sockeye migrating up the Fraser River encountered extremely high discharge levels in mid-July. This resulted in a delay of Early Stuart sockeye in the Fraser Canyon, and en route mortality estimated at 663,000 fish (Pacific Salmon Commission 1999). Sockeye from the early-timed component of the Early Summer-runs were also exposed to high discharge levels, resulting in migration delays and in en route losses of approximately 48,000 fish. Discharge levels moderated in August, and consequently, adverse affects on later timed stocks were not identified. Due to the high Fraser River discharges, stock proportions estimated from scale samples versus expected stock proportions derived from the run reconstruction model were expected to differ by larger amounts than under "normal" migration conditions.

Stock proportions estimated from DFA models were available for the Early Stuart, Early Summer (comprised of several small stocks), Chilko/Quesnel and Late Stuart/Stellako stock groups. Stock groups estimated entirely from run reconstruction models included Nadina/Gates/Pitt, Birkenhead, Weaver/Portage and Adams. The differences in catch by stock group by area for the run reconstruction estimates and the scale-based estimates are summarized in Table 6.

Catch estimates for the Early Stuart stock group included scale-based DFA model results in the six areas where scale samples were collected. In five of those areas the scale-based estimate for Early Stuart sockeye exceeded the run reconstruction estimate. The exception was the Deadman Creek to Marguerite area where Early Stuart catches were lower than expected during the last week of July, possibly because a portion of the Early Stuart sockeye run died downstream of this point. The increase in Early Stuart sockeye catch in the other five areas was primarily due to the presence of Early Stuart fish in samples for approximately two weeks longer than projected by the run reconstruction model.

In the Mission to Hope area, the scale-based estimate of Early Stuart catch was 44,508 fish, or 11,081 fish (24.9%) higher than the catch of 33,427 sockeye estimated from the run reconstruction model (Table 6). In the Hope to Sawmill Creek area the catch of Early Stuart sockeye estimated from scale samples was 10,076 fish. These catches occurred during a time that the Early Stuart sockeye migration should have previously exited the area, consequently, the run

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Table 6. Catch by stock group comparisons in 1997 (in regions and during times where the scale program was implemented).

Stock Group	Catch by Stock Group: Reconstruction Model [1]						
	Mission to Hope	Hope to Sawmill Cr.	Sawmill Cr. to Lytton	Lytton to Lillooet	Lillooet to Kelly Cr.	Deadman to Marguerite	Total
Early Stuart	33,427	0	42,147	6,030	9,342	37,208	128,154
Early Summers (Misc. stocks)	1,235		1,063	30	40	86	2,454
Nadina, Gates, Pitt							
Chilko, Quesnel	39,458	91,652	33,931	12,977	12,594	4,864	195,476
Late Stuart, Stellako	15,575	28,990	15,522	8,992	7,766	6,548	83,393
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson							
Total	89,695	120,642	92,663	28,029	29,742	48,706	409,477

Stock Group	Catch by Stock Group: Scale Data [1]						
	Mission to Hope	Hope to Sawmill Cr.	Sawmill Cr. to Lytton	Lytton to Lillooet	Lillooet to Kelly Cr.	Deadman to Marguerite	Total
Early Stuart	44,508	10,076	53,021	6,210	12,312	25,379	151,506
Early Summers (Misc. stocks)	1,693		5,816	328	144	1,912	9,893
Nadina, Gates, Pitt							
Chilko, Quesnel	32,534	83,889	21,458	12,701	10,629	7,539	168,750
Late Stuart, Stellako	11,100	27,547	11,990	8,797	7,058	13,882	80,374
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson							
Total	89,835	121,512	92,285	28,036	30,143	48,712	410,523

Stock Group	Differences in Catch by Stock Group: (Scale Data - Reconstruction Model)						
	Mission to Hope	Hope to Sawmill Cr.	Sawmill Cr. to Lytton	Lytton to Lillooet	Lillooet to Kelly Cr.	Deadman to Marguerite	Total
Early Stuart	11,081	10,076	10,874	180	2,970	-11,829	23,352
Early Summers (Misc. stocks)	458		4,753	298	104	1,826	7,439
Nadina, Gates, Pitt							
Chilko, Quesnel	-6,924	-7,763	-12,473	-276	-1,965	2,675	-26,726
Late Stuart, Stellako	-4,475	-1,443	-3,532	-195	-708	7,334	-3,019
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson							
	Differences in Catch by Stock Group (%): ((S.D.-R.M.)/S.D.)						
Early Stuart	24.9%	100.0%	20.5%	2.9%	24.1%	-46.6%	15.4%
Early Summers (Misc. stocks)	27.1%		81.7%	90.9%	72.2%	95.5%	75.2%
Nadina, Gates, Pitt							
Chilko, Quesnel	-21.3%	-9.3%	-58.1%	-2.2%	-18.5%	35.5%	-15.8%
Late Stuart, Stellako	-40.3%	-5.2%	-29.5%	-2.2%	-10.0%	52.8%	-3.8%
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson							

1. The estimated catch does not include minor stocks (present in expected proportions of less that 5%) which were estimated indirectly. Small differences in the catch totals (409,477 versus 410,523) result from the exclusion of minor stocks.

reconstruction estimate was zero. In the Sawmill Creek to Lytton area the scale-based estimate of catch was 53,021 fish, compared to the run reconstruction model estimate of 42,147 fish, a difference of 10,874 fish (20.5%). The two estimates of catch in the Lytton to Lillooet area were very similar, with the scale-based estimate of 6,210 fish being only 180 fish (2.9%) higher than the run reconstruction estimate of 6,030 fish. The scale-based estimate of catch in the Lillooet to Kelly Creek area was 12,312 fish or 2,970 fish (24.1%) higher than the run reconstruction estimate of 9,342 fish. In the Deadman Creek to Marguerite area the scale-based estimate of

Early Stuart catch was 25,379 fish, which was 11,829 fish (46.6%) lower than the run reconstruction estimate of 37,208 fish.

Analysis of the Early Summer (miscellaneous stocks) stock group incorporated scale-based DFA model results in five of the six areas where scale data were collected. Due to the low stock proportions that were projected for the stock group (less than 5% in most weeks), the application of the scale data was restricted to a maximum of two weeks in each of the five areas. The stock proportions were "tailed" using expected percentages from the run reconstruction model for the remaining weeks, when the expected stock proportions were below 5 percent. In each of the five areas where scale-based data were applied, the harvest estimates for the stock group exceeded those generated from the run reconstruction model. These areas included Mission to Hope, Sawmill Creek to Lytton, Lytton to Lillooet, Lillooet to Kelly Creek and Deadman Creek to Marguerite. The scale-based estimate of catch for each of the five areas was 1,693, 5,816, 328, 144 and 1,912 fish, respectively (Table 6). These estimates were 458 (27.1%), 4,753 (81.7%), 298 (90.9%), 104 (72.2%) and 1,826 (95.5%) fish larger than the corresponding run reconstruction estimates.

The Nadina/Gates stock group was not expected to be present in proportions exceeding 5% in any of the areas where scale data were obtained. Consequently, the estimates for this stock group were generated from the run reconstruction model.

The two summer-run stock groups had good scale-based coverage in the six areas where scale samples were collected. Due to the higher than expected proportions of Early Stuart sockeye identified in the First Nations catches, the Summer-run stock groups tended to have lower harvests when the scale-based estimates were compared to the run reconstruction estimates.

The scale-based estimate of catch for the Chilko/Quesnel stock group exceeded the run reconstruction estimate by 35.5% in the Deadman Creek to Marguerite area (7,539 fish versus 4,864 fish) (Table 6). However, the scale-based estimates were lower than projections derived from the run reconstruction model in the other five areas. Progressing upstream from Mission, the scale-based estimates and the run reconstruction estimates of catch by area were: Mission to Hope (32,534 fish versus 39,458 fish, a difference of 21.3%), Hope to Sawmill Creek (83,889 fish versus 91,652 fish, a difference of 9.3%), Sawmill Creek to Lytton (21,458 fish versus 33,931 fish, a difference of 58.1%), Lytton to Lillooet (12,701 fish versus 12,977 fish, a difference of 2.2%) and Lillooet to Kelly Creek (10,629 fish versus 12,594 fish, a difference of 18.5%) (Table 6).

The scale-based estimate of catch for the Late Stuart/Stellako stock group showed the same pattern as the Chilko/Quesnel stock group in each of the six areas (Table 6). Except for the Deadman Creek to Marguerite area, the scale-based estimate of catch was lower than the corresponding run reconstruction estimate due to the elevated Early Stuart stock group proportions in August. Following the same upstream comparisons as outlined above for the Chilko/Quesnel stock group, the scale-based estimates and the run reconstruction estimates of catch for the Late Stuart/Stellako stock group were: Mission to Hope (11,100 fish versus 15,575 fish, a difference of 40.3%), Hope to Sawmill Creek (27,547 fish versus 28,990 fish, a difference 5.2%), Sawmill Creek to Lytton (11,990 fish versus 15,522 fish, a difference of 29.5%), Lytton to Lillooet (8,797 fish versus 8,992 fish, a difference of 2.2%) and Lillooet to Kelly Creek (7,058 fish versus 7,766 fish, a difference of 10.0%). In the Deadman Creek to Marguerite area the scale-based catch estimate of 13,882 fish exceeded the run reconstruction estimate of 6,548 fish by 52.8% (Table 6).

Best Estimates of Catch by Stock Group (All Areas)

The total catch of sockeye in the Fraser River First Nations fishery in 1997 was 1,075,490 fish. Catches in the four regions of the watershed are summarized in Table 7: Steveston to Mission, Mission to Sawmill Creek, Sawmill Creek to Prince George and terminal catch regions.

Scale-based data were available to assess the catch by stock group for a component of the catch in two of the four regions (Mission to Sawmill Creek and Sawmill Creek to Prince George). Table 7. The stock groups where scale data were used for one or more weeks included Early Stuart, Early Summers (miscellaneous stocks), Chilko/Quesnel and Late Stuart/Stellako. In the Steveston to Mission and terminal areas, scale data from First Nations fishery catches were not available. However, in the Steveston to Mission area, scale data from gillnet test fisheries were used to approximate the stock composition in First Nations fisheries. The stocks present in terminal area catches were assigned stock proportions from the run reconstruction model.

The majority of the catch was distributed among three stock groups, Early Stuart (38.0%), Chilko/Quesnel (42.4%) and Late Stuart/Stellako (16.1%). The remaining 3.5% of the catch was distributed among the following stock groups: Early Summers (miscellaneous stocks) (15,539 fish), Nadina/Gates (16,048 fish), Birkenhead (5,308 fish) and Weaver/Portage (1,642 fish). The catch estimates of the minor stock groups (<5% contributions) were generally estimated with the run reconstruction model.

The best estimate of catch in the Early Stuart stock group was 408,485 fish (Table 7). This estimate exceeded the estimate produced by the run reconstruction model (384,822 sockeye) by 23,623 fish (5.8%). It is probable that the difference between the two estimates was largely caused by the increased vulnerability of Early Stuart sockeye to First Nations fisheries above Mission due to abnormally high discharge levels in the Fraser River. The difference between the two estimates would probably have been larger if the scale sampling coverage had been more extensive in the catch areas from Hope to Sawmill Creek (41.7% of the catch was estimated by scale samples) and Sawmill Creek to Lytton (74.3% of the catch was estimated by scale samples) (Table 5).

The Early Summer (miscellaneous stocks) and the Nadina/Gates stock groups were present in very small proportions relative to co-migrating stocks in 1997. Consequently, these stock groups were primarily estimated using the run reconstruction model. However, in the few scale samples where the Early Summer (miscellaneous stocks) stock group was included in the DFA models, stock proportions were higher than the run reconstruction estimates. The best estimate of catch in the Early Summer (miscellaneous stocks) stock group was 15,339 fish, which was 6,952 fish (45.3%) higher than the run reconstruction estimate of 8,387 fish (Table 7). The Nadina/Gates stock group was estimated entirely from the run reconstruction model.

The best estimates for the Chilko/Quesnel and the Late Stuart/Stellako stock groups were lower than the run reconstruction estimates. The Chilko/Quesnel best estimate was 455,514 fish, while the run reconstruction estimate was 26,711 fish (5.9%) higher at 482,225 sockeye (Table 7). Similarly, the best estimate for the Late Stuart/Stellako stock group was 173,154 sockeye, while the run reconstruction estimate of 176,283 was 3,118 fish (1.8%) higher.

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Table 7. Catch by stock group comparisons in 1997.

	Catch by Stock Group: Reconstruction Model				
Stock Group	Steveston to Mission	Mission to Sawmill Cr.	Sawmill Cr. to Prince George	Terminal Area Catches 1	Total Catch
Early Stuart	53,715	200,981	119,650	10,476	384,822
Early Summers (Misc. stocks)	1,014	5,872	1,331	170	8,387
Nadina, Gates, Pitt	3,391	7,508	5,300	600	16,799
Chilko, Quesnel	247,797	141,681	77,147	15,600	482,225
Late Stuart, Stellako	78,472	47,128	44,203	6,480	176,283
Birkenhead	5,308	0	0	0	5,308
Weaver, Portage & Misc. Late Runs	813	514	339	0	1,666
Adams & Misc. Late S. Thompson	0	0	0	0	0
Total	390,510	403,684	247,970	33,326	1,075,490

1. Terminal Areas include the Thompson River, Chilcotin River, Nechako River and Stuart River.

	Catch by Stock Group: Scale Data and Reconstruction Model (Best Estimates)				
Stock Group	Steveston to Mission	Mission to Sawmill Cr.	Sawmill Cr. to Prince George	Terminal Area Catches 1	Total Catch
Early Stuart	53,715	222,326	121,959	10,485	408,485
Early Summers (Misc. stocks)	1,014	5,879	8,276	170	15,339
Nadina, Gates, Pitt	3,391	6,768	5,287	602	16,048
Chilko, Quesnel	247,797	126,987	65,130	15,600	455,514
Late Stuart, Stellako	78,472	41,223	46,990	6,469	173,154
Birkenhead	5,308	0	0	0	5,308
Weaver, Portage & Misc. Late Runs	813	501	328	0	1,642
Adams & Misc. Late S. Thompson	0	0	0	0	0
Total	390,510	403,684	247,970	33,326	1,075,490

1. Terminal Areas include the Thompson River, Chilcotin River, Nechako River and Stuart River.

	Differences (Best Estimates minus Run Reconstruction Model Estimates)				
Stock Group	Steveston to Mission	Mission to Sawmill Cr.	Sawmill Cr. to Prince George	Terminal Area Catches 1	% Difference
Early Stuart		21,345	2,309		5.8%
Early Summers (Misc. stocks)		7	6,945		45.3%
Nadina, Gates, Pitt					
Chilko, Quesnel		-14,694	-12,017		-5.9%
Late Stuart, Stellako		-5,905	2,787		-1.8%
Birkenhead					
Weaver, Portage & Misc. Late Runs					
Adams & Misc. Late S. Thompson					

1. Terminal Areas include the Thompson River, Chilcotin River, Nechako River and Stuart River.

1998 Results

Application of Scale Data to Catches in First Nations Fisheries

The implementation of the scale-sampling program improved in 1998. Samples were obtained from all of the designated sampling sites with the exception of Stoner Creek. In the Mission to Hope catch area five samples were obtained on the following dates: July 29-August 1, August 6-7, August 12-15, August 18-22 and from August 25-28 (Appendix Table 3). DFA models were used to estimate the stock composition from each of these samples. The catch from August 4-5 was interpolated from the July 29-August 1 and August 6-7 samples. The catch represented by the scale samples collected from July 29 to August 28 was 83,027 fish, which was 94.3% of the season catch total of 88,065 sockeye in the Mission to Hope area (Table 8). Stock composition estimates from catches occurring before July 29 and after August 28 were derived from the run reconstruction model.

Table 8. Proportion of catch estimated from scales in 1998.

	Proportion Of Catch Represented By Scale Samples (Targeted Catch Areas Only)		
Catch Area	Scale-based Catch [1]	Total Catch	% of Scale-based to Total Catch
Mission to Hope	83,027	88,065	94.3%
Hope to Sawmill Creek	186,202	187,901	99.1%
Sawmill Creek to Lytton	69,519	76,721	90.6%
Lytton to Lillooet	14,906	24,980	59.7%
Lillooet to Kelly Creek	24,840	24,981	99.4%
Deadman to Marguerite	7,376	8,081	91.3%
Total	385,870	410,729	93.9%

1. The catch represented by scale samples includes the estimated catch of minor stocks (present in expected proportions of less than 5%). The minor stocks were estimated using a tailing methodology.

In the Hope to Sawmill Creek catch area five scale samples were collected. The dates of the samples were July 29-August 1, August 4-7, August 12-15, August 18-22 and August 25-28 (Appendix Table 3). This sampling accounted for 99.1% of the total catch for the area. The catch corresponding to the sampling dates was 186,202 sockeye, while the total catch for the season was 187,901 sockeye (Table 8). The small harvest occurring prior to July 29 and after August 28 was apportioned into stock groups using the run reconstruction model.

In the Sawmill Creek to Lytton area seven scale samples were obtained, from August 1 to September 10. The dates of the samples were August 1-2, August 5-7, August 11-16, August 17-21, August 24-30, August 31-September 5 and September 7-10 (Appendix Table 3). Scale data were applied to four additional harvest periods from August 2 to September 7 by interpolation. In total, scale-based stock composition estimates were applied to a harvest of 69,519 fish, or 90.6% of the total catch for the area (Table 8). Catches taken before August 1 and after September 10 were assigned stock proportions from the run reconstruction model.

In the Lytton to Lillooet area four scale samples were obtained on the following dates: July 31-August 2, August 5-9, August 10-16 and August 17-21 (Appendix Table 3). The catch from August 3-4 was assigned stock proportions by interpolating scale data from the July 31-August 2 and August 5-9 samples. The catch represented by scale samples collected in the Lytton to Lillooet area was 14,906 fish, or 59.7% of the total harvest of 24,980 sockeye (Table 8). The remaining catch was apportioned into stock groups using the run reconstruction model.

In the Lillooet to Kelly Creek area seven scale samples were collected, providing comprehensive scale-based coverage of the harvest from July 27-September 13. The dates of the samples were July 27-August 2, August 3-9, August 10-16, August 17-23, August 24-30, August 31-September 6 and September 7-13 (Appendix Table 3). The catch represented by scale samples obtained in the Lillooet to Kelly Creek area was 24,840 fish, or 99.4% of the total harvest of 24,981 fish (Table 8). The small catch not covered by stock proportions generated by scale-based DFA models was apportioned into stock groups using the run reconstruction model.

In the Deadman Creek to Marguerite catch area five scale samples were obtained: July 27-August 2, August 3-9, August 10-16, August 17-23 and August 24-30 (Appendix Table 3). The samples from July 21 – August 30 corresponded to a catch of 7,376 fish, which represented 91.3% of the total catch for the area of 8,081 fish (Table 8).

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In total, 33 samples from six catch regions were collected in 1998. Some interpolation of samples to cover additional catch dates was required, however, the majority of the stock composition estimates were from the scale samples. The catch represented by the scale samples, including interpolations, was 385,870 fish, or 93.9% of the 410,729 fish harvested in the Fraser River between Mission and Marguerite (Table 8).

Comparison of DFA and Run Reconstruction Catch Estimates

In 1998 there were serious migration concerns for many Fraser River sockeye runs. Abnormally high water temperatures in July and August were believed to have caused high en route and pre-spawning mortality of Early Stuart, Early Summer and Summer-run stock groups (Pacific Salmon Commission 2000). Large differences were also observed between Mission hydroacoustic estimates of Late-run stock groups and subsequent estimates of upstream abundance of these stocks. These latter differences were probably associated with the unusual upstream migration timing of Late-run stocks in 1998 (Pacific Salmon Commission 2000). A significant issue regarding the analysis of First Nations fishery catches in 1998 is whether the unusual migration conditions affected the vulnerability of the different sockeye stocks to harvest. The assessment of scale samples collected from the First Nations fisheries is important in addressing this concern.

In 1998, stock proportions derived from the scale-based models were incorporated into the estimates of the Early Stuart, Early Summer (miscellaneous stocks), Chilko/Quesnel, Late Stuart/Stellako and Adams/Lower Shuswap stock groups. The differences in catch by stock group by area for estimates derived using the run reconstruction model and the scale-based DFA estimates are summarized in Table 9.

Scale samples were collected from First Nations fisheries in six areas, from Mission to Marguerite. However, in part because of restricted fishing opportunities, the first scale samples were not obtained until late July. Consequently, catch estimates for the Early Stuart stock group included scale-based estimates in only one week in each of two areas, Lillooet to Kelly Creek and Deadman Creek to Marguerite. While both of the scale-based results yielded smaller catch estimates than the run reconstruction estimates, the absence of samples from June and through most of July may have affected the reliability of the scale-based estimates during the period of the Early Stuart migration.

In the Lillooet to Kelly Creek area, the scale-based estimate of Early Stuart catch was 88 fish, which was 60 fish (68.2%) lower than the run reconstruction estimate of 148 fish (Table 9). In the Deadman Creek to Marguerite area the scale-based estimate of catch was 335 sockeye and the run reconstruction estimate was 1,032 sockeye, a difference of 697 fish (208.1%).

The Early Summer (miscellaneous stocks) stock group incorporated scale-based DFA model results in each of the six areas where scale data were collected. However, because of smaller than expected stock proportions the application of these scale data were restricted to two weeks. In three of the six areas where scale data were used, the catch estimates for the Early Summer (miscellaneous stocks) stock group were higher than the run reconstruction estimates. These areas include: Sawmill Creek to Lytton (15,854 fish versus 6,121 fish, for a difference of 9,733 fish (61.4%), Lillooet to Kelly Creek (488 fish versus 126 fish, for a difference of 362 fish (74.2%), and Deadman Creek to Marguerite (191 fish versus 128 fish, for a difference of 63 fish (33.0%) (Table 9). In the remaining areas the scale-based estimates of catch for the Early

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Table 9. Catch by stock group comparisons in 1998 (in regions and during times where the scale program was implemented).

Stock Group	Catch by Stock Group: Reconstruction Model[1]						
	Mission to Hope	Hope to Sawmill Cr.	Sawmill Cr. to Lytton	Lytton to Lillooet	Lillooet to Kelly Cr.	Deadman to Marguerite	Total
Early Stuart					148	1,032	1,180
Early Summers (Misc. stocks)	6,085	18,502	6,121	64	126	128	31,026
Nadina, Gates, Pitt							
Chilko, Quesnel	54,505	116,086	43,878	11,096	18,180	3,763	247,508
Late Stuart, Stellako	17,913	42,275	14,463	3,484	6,229	2,269	86,633
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson	3,758	7,546	4,454				15,758
Total	82,261	184,409	68,916	14,644	24,683	7,192	382,105

Stock Group	Catch by Stock Group: Scale Data[1]						
	Mission to Hope	Hope to Sawmill Cr.	Sawmill Cr. to Lytton	Lytton to Lillooet	Lillooet to Kelly Cr.	Deadman to Marguerite	Total
Early Stuart					88	335	423
Early Summers (Misc. stocks)	5,996	14,960	15,854	60	488	191	37,549
Nadina, Gates, Pitt							
Chilko, Quesnel	48,032	112,476	27,546	8,819	18,421	4,212	219,506
Late Stuart, Stellako	16,986	48,548	8,299	5,751	5,708	2,503	87,795
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson	11,159	8,358	17,316				36,833
Total	82,173	184,342	69,015	14,630	24,705	7,241	382,106

Stock Group	Differences in Catch by Stock Group: (Scale Data - Reconstruction Model)						
	Mission to Hope	Hope to Sawmill Cr.	Sawmill Cr. to Lytton	Lytton to Lillooet	Lillooet to Kelly Cr.	Deadman to Marguerite	Total
Early Stuart					-60	-697	-757
Early Summers (Misc. stocks)	-89	-3,542	9,733	-4	362	63	6,523
Nadina, Gates, Pitt							
Chilko, Quesnel	-6,473	-3,610	-16,332	-2,277	241	449	-28,002
Late Stuart, Stellako	-927	6,273	-6,164	2,267	-521	234	1,162
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson	7,401	812	12,862				21,075
	Differences in Catch by Stock Group (%): ((S.D.-R.M.)/S.D.)						
Early Stuart					-68.2%	-208.1%	-179.0%
Early Summers (Misc. stocks)	-1.5%	-23.7%	61.4%	-6.7%	74.2%	33.0%	17.4%
Nadina, Gates, Pitt							
Chilko, Quesnel	-13.5%	-3.2%	-59.3%	-25.8%	1.3%	10.7%	-12.8%
Late Stuart, Stellako	-5.5%	12.9%	-74.3%	39.4%	-9.1%	9.3%	1.3%
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson	66.3%	9.7%	74.3%				57.2%

1. The estimated catch does not include minor stocks (present in expected proportions of less that 5%) which were estimated indirectly. Small differences in the catch totals result from the exclusion of minor stocks.

Summer stock group were lower than the estimates generated by the run reconstruction model. The differences were small with the exception of the Hope to Sawmill Creek area. The DFA model estimates and run reconstruction catch comparisons were: Mission to Hope (5,996 sockeye versus 6,085 sockeye, for a difference of 89 fish (1.5%), Hope to Sawmill Creek (14,960 sockeye versus 18,502 sockeye, for a difference of 3,542 fish (23.7%) and Lytton to Lillooet (60 sockeye versus 64 sockeye, for a difference of 4 fish (6.7%).

The Nadina/Gates stock group was not expected to exceed 5% in any of the areas where scale data were obtained. Consequently the estimates for this stock group were generated using the run reconstruction model.

There was good scale-based coverage for the two Summer-run stock groups from the six areas where scale samples were collected. In the areas downstream of Lillooet, the DFA estimate of catch for the Chilko/Quesnel stock group consistently identified fewer fish than the run reconstruction model. In the two catch areas upstream of Lillooet where scale samples were collected, the DFA estimates were marginally higher than the run reconstruction estimates. In sequence, moving upstream from the Mission to Hope area to the Lytton to Lillooet area, the scale-based estimates and the run reconstruction estimates of catch were: 48,032 sockeye versus 54,505 sockeye for a difference of 6,473 fish (13.5%), 112,476 sockeye versus 116,086 sockeye for a difference of 3,610 fish (3.2%), 27,546 sockeye versus 43,878 sockeye for a difference of 16,332 fish (59.3%), and 8,819 sockeye versus 11,096 sockeye for a difference of 2,227 fish (25.8%) (Table 9). In the Lillooet to Kelly Creek area the DFA estimate of catch was 18,421 fish, which was within 1.3% of the run reconstruction estimate of 18,180 sockeye. In the Deadman Creek to Marguerite area, the DFA estimate of catch (4,212 fish) was higher than the run reconstruction estimate (3,763 fish) by 449 fish (10.7%).

Examination of estimates for the Late Stuart/Stellako stock group did not show any consistent directional differences between the scale-based estimate of catch and the run reconstruction estimate. In three of the catch areas the DFA estimate of catch was higher than the run reconstruction estimate, while it was lower in the remaining areas. The areas where the scale-based estimate of catch exceeded the run reconstruction estimate were: Hope to Sawmill Creek (48,548 fish versus 42,275 fish) for a difference of 6,273 sockeye (12.9%), Lytton to Lillooet (5,751 fish versus 3,484 fish) for a difference of 2,267 sockeye (39.4%), and Deadman Creek to Marguerite (2,503 fish versus 2,269 fish) for a difference of 234 sockeye (9.3%) (Table 9). The three areas where the DFA estimate of catch were lower included: Mission to Hope (16,986 fish versus 17,913 fish) for a difference of 927 sockeye (5.5%), Sawmill Creek to Lytton (8,299 fish versus 14,463 fish) for a difference of 6,164 sockeye (74.3%), and Lillooet to Kelly Creek (5,708 fish versus 6,229 fish) for a difference of 521 sockeye (9.1%).

The final stock group estimated using scale-based DFA model results was the Adams/Lower Shuswap stock group. This stock group migrates up the Thompson River; consequently, scale-based estimates of catch were only present from the catch areas downstream of Lytton. DFA catch estimates for this stock group were higher than those from the run reconstruction model, particularly in the Mission to Hope and Sawmill Creek to Lytton catch areas. In the Mission to Hope area the DFA estimate of catch was 11,159 fish, which was 7,401 fish (66.3%) higher than the run reconstruction estimate of 3,758 sockeye (Table 9). The DFA estimate of catch in the Hope to Sawmill Creek area was 8,358 fish, which exceeded the run reconstruction estimate of 7,546 fish by 812 sockeye (9.7%). In the Sawmill Creek to Lytton area the DFA estimate of catch was 17,316 fish, much higher (12,862 fish, 74.3%) than the run reconstruction estimate of 4,454 fish.

Best Estimates of Catch by Stock Group (All Areas)

The total catch of sockeye in the Fraser River First Nations fishery in 1998 was 643,476 fish (Table 10). This catch was split into four broad areas: Steveston to Mission, Mission to Sawmill Creek, Sawmill Creek to Prince George and terminal catch regions.

Scale-based data were available to assess catch by stock group for a component of the catch in two of the four regions (Mission to Sawmill Creek and Sawmill Creek to Prince George).

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Table 10. Catch by stock group comparison in 1998.

Stock Group	Catch by Stock Group: Reconstruction Model				
	Steveston to Mission	Mission to Sawmill Cr.	Sawmill Cr. to Prince George	Terminal Area Catches 1	Total Catch
Early Stuart	108	6,268	5,935	3,016	15,327
Early Summers (Misc. stocks)	16,353	24,819	7,233	812	49,217
Nadina, Gates, Pitt	4,438	1,918	1,258	311	7,925
Chilko, Quesnel	106,726	170,664	85,543	36,262	399,195
Late Stuart, Stellako	29,673	60,237	29,634	10,204	129,748
Birkenhead	8,432	0	0	0	8,432
Weaver, Portage & Misc. Late Runs	2,149	716	301	0	3,166
Adams & Misc. Late S. Thompson	10,717	11,344	4,859	3,546	30,466
Total	178,596	275,966	134,763	54,151	643,476

1. Terminal Areas include the Thompson River, Chilcotin River, Nechako River and Stuart River.

Stock Group	Catch by Stock Group: Scale Data and Reconstruction Model (Best Estimates)				
	Steveston to Mission	Mission to Sawmill Cr.	Sawmill Cr. to Prince George	Terminal Area Catches 1	Total Catch
Early Stuart	108	6,264	5,181	3,019	14,572
Early Summers (Misc. stocks)	16,353	21,188	17,393	853	55,787
Nadina, Gates, Pitt	4,438	2,089	1,120	318	7,965
Chilko, Quesnel	106,726	160,579	67,515	36,262	371,082
Late Stuart, Stellako	29,673	65,583	25,441	10,194	130,891
Birkenhead	8,432	0	0	0	8,432
Weaver, Portage & Misc. Late Runs	2,149	706	273	0	3,128
Adams & Misc. Late S. Thompson	10,717	19,557	17,840	3,505	51,619
Total	178,596	275,966	134,763	54,151	643,476

1. Terminal Areas include the Thompson River, Chilcotin River, Nechako River and Stuart River.

Stock Group	Differences (Best Estimates minus Run Reconstruction Model Estimates)				
	Steveston to Mission	Mission to Sawmill Cr.	Sawmill Cr. to Prince George	Terminal Area Catches 1	% Difference
Early Stuart		-4	-754		-5.2%
Early Summers (Misc. stocks)		-3,631	10,160		11.7%
Nadina, Gates, Pitt					
Chilko, Quesnel		-10,085	-18,028		-7.6%
Late Stuart, Stellako		5,346	-4,193		0.9%
Birkenhead					
Weaver, Portage & Misc. Late Runs					
Adams & Misc. Late S. Thompson		8,213	12,981		41.1%

1. Terminal Areas include the Thompson River, Chilcotin River, Nechako River and Stuart River.

Scale data were used for the Early Stuart, Early Summers (miscellaneous stocks), Chilko/Quesnel, Late Stuart/Stellako and Adams/Lower Shuswap stock groups. In the two regions where scale data were not available, either scale data from gillnet test fisheries were used to estimate the stock composition in First Nations fisheries (Steveston to Mission area) or the run reconstruction model was used to generate estimates of catch by stock group (terminal areas).

The majority of the catch was concentrated in the two Summer-run stock groups, Chilko/Quesnel (57.7%) and Late Stuart/Stellako (20.3%). There was also harvest on the Early Summers (miscellaneous stocks) (8.7%), Adams/Lower Shuswap (8.0%), Early Stuart (2.3%), Nadina/Gates (1.2%), Birkenhead (1.3%) and Weaver/Portage (0.5%) stock groups.

The best estimate of catch of the Early Stuart stock group was 14,572 fish, which was slightly lower (5.2%) than the run reconstruction estimate of 15,327 fish (Table 10). The difference could be attributed to the Sawmill Creek to Prince George area, which was the only region where scale data were applied.

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The Early Summer (miscellaneous) stock group was primarily estimated using the run reconstruction model, however limited application of scale data was utilized in the catch areas upstream of Mission. The best estimate of catch in the Early Summer stock group was 55,787 sockeye, which was slightly higher (11.7%) than the estimate of 49,217 sockeye produced from the run reconstruction model (Table 10). Catches of the other Early Summer-run stock group, Nadina/Gates (7,965 fish), were estimated entirely from the run reconstruction model.

The best estimate for the Chilko/Quesnel group was 371,082 fish and the run reconstruction estimate was (7.6%) higher at 399,195 fish (Table 10). The Late Stuart/Stellako stock group had a best estimate of catch (130,891 sockeye) which was within 0.9% of the run reconstruction estimate of 129,748 sockeye.

There were higher than expected catches of the Adams/Lower Shuswap stock group in areas where scale data were collected. The best estimate of catch was 51,619 fish, which exceeded by 41.1% the run reconstruction estimate of 30,466 fish (Table 10). It is possible that the very early upstream migration timing of the Adams/Lower Shuswap stock group, and the associated stresses on the Late-run fish from this unusual behavior, increased their vulnerability to in-river fisheries relative to co-migrating Summer-run stocks. These results show the importance of obtaining direct measures of stock group harvests in First Nations fisheries, particularly during periods of unusual environmental conditions, or when unusual behavior is exhibited by migrating sockeye stocks.

1999 Results

Application of Scale Data to Catches in First Nations Fisheries

In 1999, the scale sampling coverage from the designated sampling sites was very limited. This was due primarily to the restricted fishing time (and subsequently few sampling opportunities) resulting from conservation closures that were imposed during the 1999 fishery. In the Mission to Hope catch area, one scale sample was obtained from a fishery occurring from August 7-8 (Appendix Table 4). The corresponding catch on those days was 5,589 fish, which represented 21.0% of the season total of 26,577 fish (Table 11). Catches taken outside of those dates were apportioned into stock groups using the run reconstruction model.

In the Hope to Sawmill Creek catch area, three scale samples were obtained: July 26-31, August 5-7 and August 8-10 (Appendix Table 4). Stock composition estimates were derived from DFA models for these dates. The stock composition for August 1-4 was estimated by interpolation from the July 26-31 and August 5-7 samples. The catch for the period July 26 to August 10 was 68,447 fish, which was 98.1% of the season catch for the area of 69,775 sockeye (Table 11). Catches taken prior to July 26 and after August 10 were assigned stock compositions using the run reconstruction model.

Scale samples were not obtained in the catch area from Sawmill Creek to Lytton. Scale-based data were applied to catches in this area by extrapolating data collected in the Hope to Sawmill Creek area, with a two-day time lag. This provided scale-based DFA stock composition estimates from July 28 to August 12. The harvest during this period was 55,719 sockeye, which was 91.3% of the season catch total of 61,042 sockeye harvested in the area (Table 11). The remaining catch was apportioned into stock groups using the run reconstruction model.

Scale samples were also not obtained from the catch area between Lytton to Lillooet, and therefore scale data were extrapolated from lower river catch areas. Appropriate time lags were applied, and adjustments were made to stock groupings to compensate for the absence of stocks

Table 11. Proportion of catch estimated from scales in 1999.

	Proportion Of Catch Represented By Scale Samples (Targeted Catch Areas Only)		
Catch Area	Scale-based Catch [1]	Total Catch	% of Scale-based to Total Catch
Mission to Hope	5,589	26,577	21.0%
Hope to Sawmill Creek	68,447	69,775	98.1%
Sawmill Creek to Lytton	55,719	61,042	91.3%
Lytton to Lillooet	4,552	5,892	77.3%
Lillooet to Kelly Creek	5,102	5,891	86.6%
Deadman to Marguerite	266	8,653	3.1%
Total	139,675	177,830	78.5%

1. The catch represented by scale samples includes the estimated catch of minor stocks (present in
expected proportions of less than 5%). The minor stocks were estimated using a tailing methodology.

migrating up the Thompson River. The estimated catch harvested from July 30 to August 14 was 4,552 fish, which was 77.3% of the total catch for the area of 5,892 fish (Table 11). The remaining harvest was apportioned into stock groups using the run reconstruction model.

Three scale samples were obtained from the First Nations fishery occurring between Lillooet to Kelly Creek. The fishery dates covered by the samples were August 3-9, August 10-16 and August 18-22 (Appendix Table 4). The stock composition for August 17 was interpolated from the August 10-16 and August 18-22 samples. Scale-based stock composition estimates were produced for the period August 3-22. The harvest during this period was 5,102 fish, which was 86.6% of the total catch for the area of 5,891 fish (Table 11). The small remaining catch was assigned stock proportions using the run reconstruction model.

One scale sample was collected from the Deadman Creek to Marguerite area from August 5-6, and the fishery catch corresponding to the sample was 266 fish (Appendix Table 4). This was 3.1% of the total catch for the area of 8,653 sockeye (Table 11). Stock composition estimates from the run reconstruction model were assigned to the catch taken outside of this two-day sample.

In total, eight scale samples were obtained from four sampling sites in 1999. The application of scale-based DFA analyses to First Nations catches was expanded through interpolation of samples within areas, and through extrapolation of samples between adjacent areas. Scale-based stock proportions were applied to a catch of 139,675 fish, or 78.5% of the total catch of 177,830 sockeye harvested in the Fraser River between Mission and Marguerite (Table 11).

Comparison of DFA and Run Reconstruction Catch Estimates

In 1999, as in 1997, abnormally high water flows in the Fraser River during the Early Stuart, Early Summer and a portion of the Summer-run migrations created upstream passage difficulties for a number of sockeye stocks. Some stocks exposed to the high discharge levels experienced large en route and pre-spawning mortalities (Pacific Salmon Commission 2001). The high Fraser River discharges during 1999 may have affected the upstream timing of Fraser sockeye stocks, as well as their relative availability and vulnerability to First Nations fisheries.

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Catch estimates for stock groups estimated entirely from the run reconstruction model in 1999 included Birkenhead, Weaver/Portage and Adams/Lower Shuswap. Stock proportions derived from the DFA models were incorporated into the estimates of the Early Stuart, Early Summer (miscellaneous stocks), Nadina/Gates, Chilko/Quesnel and Late Stuart/Stellako stock groups. The differences in catch by stock group by area for estimates derived using the run reconstruction model and the DFA estimates are summarized in Table 12.

Catch estimates for the Early Stuart stock group included scale-based results in three of the four areas where scale samples were collected. Extrapolated data provided indirect scale-based estimates in two additional areas. The only area where scale-based estimates of catch were not available was Mission to Hope. The DFA estimate of Early Stuart catch in four of the five areas upstream of Hope was higher than the estimate generated from the run reconstruction model. The elevated Early Stuart catch was likely due to the presence of Early Stuart fish in catches for a longer duration than expected, due to the migration delay they experienced in response to high Fraser River discharges.

In the Hope to Sawmill Creek area the scale-based estimate of Early Stuart catch was 9,338 sockeye, which was 8,844 fish (94.7%) higher than the run reconstruction estimate of 494 sockeye. In the Sawmill Creek to Lytton area, the DFA estimate of catch was 7,058 fish, while the run reconstruction estimate was 167 fish, a difference of 6,891 fish (97.6%). The similarity of the difference between the two estimates in the Hope to Sawmill Creek and Sawmill Creek to Lytton areas was because the scale data applied to the latter area were extrapolated from the former. This also applies to the Lytton to Lillooet area, where the DFA estimate of catch was 722 fish and the run reconstruction estimate of catch was 15 fish. The DFA estimate of catch in the Lillooet to Kelly Creek area was 1,041 fish, (99.8%) 1,039 fish higher than the run reconstruction estimate of 2 fish. In the Deadman Creek to Marguerite area, the DFA estimate of Early Stuart catch was 22 sockeye, while the run reconstruction estimate was 26 sockeye, a difference of 4 fish (18.2%).

The Early Summer (miscellaneous stocks) stock group incorporated scale-based results in the Hope to Sawmill Creek area, and these data were extrapolated to the Sawmill Creek to Lytton and Lytton to Lillooet areas. In the Hope to Sawmill Creek area, as well as the two adjacent upstream areas where the scale data were extrapolated, the DFA estimate of catch for the Early Summer (miscellaneous stocks) stock group was higher than the run reconstruction estimate. As was the case with the Early Stuart stock group, the higher than expected catch was likely due to the migration delays caused by the high Fraser River discharge. The DFA estimate of catch for each of the three areas where scale data were applied was 15,873, 12,380 and 167 fish, respectively. These estimates were 4,187 fish (26.4%), 2,525 fish (20.4%) and 32 fish (19.2%) larger than the corresponding estimate derived from the run reconstruction model (Table 12).

The Nadina/Gates stock group was estimated with one week of scale-based data in the Mission to Hope area and three weeks in the Hope to Sawmill Creek area. Scale data were also applied through extrapolation in the Sawmill Creek to Lytton and Lytton to Lillooet areas. In the Mission to Hope area the DFA estimate of catch (56 fish) was lower than the run reconstruction estimate (276 fish) by 220 fish (392.9%) (Table 12). In the Hope to Sawmill Creek area, where more complete scale data were available, the DFA estimate of catch (10,908 fish) exceeded the run reconstruction estimate (4,704 fish) by 6,204 fish (56.9%). The DFA estimate of catch in the Sawmill Creek to Lytton (8,592 fish) and Lytton to Lillooet (679 fish) areas, were larger than the run reconstruction estimates (3,506 and 238 fish) by similar proportions as were observed in the Hope to Sawmill Creek area.

Table 12. Catch by stock group comparisons in 1999 (in regions and during times where the scale program was implemented).

Stock Group	Catch by Stock Group: Reconstruction Model [1]						
	Mission to Hope	Hope to Sawmill Cr.	Sawmill Cr. to Lytton	Lytton to Lillooet	Lillooet to Kelly Cr.	Deadman to Marguerite	Total
Early Stuart		494	167	15	2	26	704
Early Summers (Misc. stocks)		11,686	9,855	135			21,676
Nadina, Gates, Pitt	276	4,704	3,506	238			8,724
Chilko, Quesnel	3,434	38,083	32,881	3,194	3,664	93	81,349
Late Stuart, Stellako	875	13,481	9,310	969	1,120	117	25,872
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson							
Total	4,585	68,448	55,719	4,551	5,101	266	138,670

Stock Group	Catch by Stock Group: Scale Data [1]						
	Mission to Hope	Hope to Sawmill Cr.	Sawmill Cr. to Lytton	Lytton to Lillooet	Lillooet to Kelly Cr.	Deadman to Marguerite	Total
Early Stuart		9,338	7,058	722	1,041	22	18,181
Early Summers (Misc. stocks)		15,873	12,380	167			28,420
Nadina, Gates, Pitt	56	10,908	8,592	679			20,235
Chilko, Quesnel	3,859	17,719	15,063	1,587	3,139	80	41,447
Late Stuart, Stellako	671	14,610	12,626	1,396	658	149	30,110
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson							
Total	4,586	68,448	55,719	4,551	5,102	266	138,672

Stock Group	Differences in Catch by Stock Group: (Scale Data - Reconstruction Model)						
	Mission to Hope	Hope to Sawmill Cr.	Sawmill Cr. to Lytton	Lytton to Lillooet	Lillooet to Kelly Cr.	Deadman to Marguerite	Total
Early Stuart		8,844	6,891	707	1,039	-4	17,477
Early Summers (Misc. stocks)		4,187	2,525	32			6,744
Nadina, Gates, Pitt	-220	6,204	5,086	441			11,511
Chilko, Quesnel	425	-20,364	-17,818	-1,607	-525	-13	-39,902
Late Stuart, Stellako	-204	1,129	3,316	427	-462	32	4,238
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson							
	Differences in Catch by Stock Group (%): ((S.D.-R.M.)/S.D.)						
Early Stuart		94.7%	97.6%	97.9%	99.8%	-18.2%	96.1%
Early Summers (Misc. stocks)		26.4%	20.4%	19.2%			23.7%
Nadina, Gates, Pitt	-392.9%	56.9%	59.2%	64.9%			56.9%
Chilko, Quesnel	11.0%	-114.9%	-118.3%	-101.3%	-16.7%	-16.3%	-96.3%
Late Stuart, Stellako	-30.4%	7.7%	26.3%	30.6%	-70.2%	21.5%	14.1%
Birkenhead							
Weaver, Portage & Misc. Late Runs							
Adams & Misc. Late S. Thompson							

1. The estimated catch does not include minor stocks (present in expected proportions of less that 5%) which were estimated indirectly.

The two Summer-run stock groups were estimated with scale data in each of the areas and weeks where scale samples were collected. The DFA estimate of catch for the Chilko/Quesnel stock group estimated more fish than the run reconstruction model in one area (Mission to Hope), and fewer fish in five areas (Hope to Sawmill Creek, Sawmill Creek to Lytton, Lytton to Lillooet, Lillooet to Kelly Creek and Deadman Creek to Marguerite). In the Mission to Hope area, the DFA estimate of catch (3,859 fish) was eleven percent higher than the reconstruction estimate (3,434 fish) (Table 12). In the five areas spanning from Hope to Marguerite, the DFA estimates of catch were: Hope to Sawmill Creek (17,719 sockeye), Sawmill Creek to Lytton (15,063 sockeye), Lytton to Lillooet (1,587 sockeye), Lillooet to Kelly Creek

(3,139 sockeye) and Deadman Creek to Marguerite (80 sockeye). The corresponding run reconstruction catch estimates in each of the five areas were larger at 38,043, 32,881, 3,194, 3,664 and 93 fish, respectively. The discrepancies by area were 20,364 fish (114.9%), 17,818 fish (118.3%), 1,607 fish (101.3%), 525 fish (16.7%) and 13 fish (16.3%).

The DFA estimates of catch for the Late Stuart/Stellako stock group were lower than the run reconstruction estimates in two areas: Mission to Hope (671 fish versus 875 fish, 30.4%) and Lillooet to Kelly Creek (658 fish versus 1,120 fish, 70.2%) (Table 12). Conversely, the DFA estimates were higher than the run reconstruction estimates in the remaining four areas: Hope to Sawmill Creek (14,620 versus 13,481, 7.7%), Sawmill Creek to Lytton (12,626 fish versus 9,310 fish, 26.3%), Lytton to Lillooet (1,396 fish versus 969 fish, 30.6%) and Deadman Creek to Marguerite (149 fish versus 117 fish, 21.5%).

Best Estimates of Catch by Stock Group (All Areas)

The total catch of sockeye in the Fraser River First Nations fishery in 1999 was only 251,118 fish, primarily due to harvest closures that were imposed for conservation. Catches in four regions of the watershed: Steveston to Mission, Mission to Sawmill Creek, Sawmill Creek to Prince George and terminal areas are summarized in Table 13. Limited numbers of scale samples were available to assess the catch by stock group in two of the four regions (Mission-Sawmill Creek and Sawmill Creek-Prince George).

The best estimates of catch of the Birkenhead (618 fish), Weaver/Portage (2,741 fish) and Adams/Lower Shuswap (8,421 fish) stock groups were all relatively minor, comprising less than five percent of the total catch (Table 13). The catches of these stock groups were estimated using the run reconstruction model.

The best estimate of catch for the Early Stuart stock group was 22,326 fish, which was 17,935 fish (80.3%) higher than the estimate produced by the run reconstruction model (4,391 fish) (Table 13). As in 1997, the difference between the two estimates was probably a result of the increased vulnerability of the Early Stuart stock group to First Nations fisheries above Mission due to abnormally high discharge levels in the Fraser River. High water levels slow the sockeye migration and prolong the period that early-timed stocks are vulnerable to First Nations fisheries in the Fraser Canyon and areas upstream of the Fraser Canyon.

The best estimate of catch in the Early summer (miscellaneous) stock group was 39,057 fish (Table 13). This estimate was 6,711 fish (17.2%) higher than the run reconstruction estimate. Similarly, the best estimate of catch of the Nadina/Gates stock group (27,550 fish) exceeded the run reconstruction estimate (16,262 fish) by 11,288 fish (41.0%). The migration of these early-timed stock groups was affected by Fraser River discharges, and this was likely responsible for the increased catches relative to those expected from the run reconstruction model.

The high discharges in the Fraser River which caused the best estimates of the Early Stuart and Early Summer-run stock groups to be larger than expected, resulted in lower than expected catches in the Chilko/Quesnel stock group. The best estimate of catch for this group was 97,209 fish, which was 39,718 fish (40.9%) lower than the run reconstruction estimate of 136,927 sockeye (Table 13). However, the best estimate of catch for the Late Stuart/Stellako stock group was 53,196 fish, which was 3,784 fish (7.1%) higher than the run reconstruction estimate of 49,412 fish. The reason for the directional difference in catch estimates between the Chilko/Quesnel and Late Stuart/Stellako stock groups is unclear. It is possible that stock identification models underestimated the catch of Early Stuart sockeye and overestimated the catch of Late Stuart/Stellako sockeye due to similarities in scale patterns between the two groups.

Table 13. Catch by stock group comparisons in 1999.

	Catch by Stock Group: Reconstruction Model				
Stock Group	Steveston to Mission	Mission to Sawmill Cr.	Sawmill Cr. to Prince George	Terminal Area Catches 1	Total Catch
Early Stuart	248	2,011	1,775	357	4,391
Early Summers (Misc. stocks)	5,127	16,214	10,979	26	32,346
Nadina, Gates, Pitt	4,681	6,486	4,905	190	16,262
Chilko, Quesnel	16,861	52,777	47,529	19,760	136,927
Late Stuart, Stellako	5,282	18,679	15,960	9,491	49,412
Birkenhead	618	0	0	0	618
Weaver, Portage & Misc. Late Runs	2,704	5	32	0	2,741
Adams & Misc. Late S. Thompson	5,345	180	323	2,573	8,421
Total	40,866	96,352	81,503	32,397	251,118

1. Terminal Areas include the Thompson River, Chilcotin River, Nechako River and Stuart River.

	Catch by Stock Group: Scale Data and Reconstruction Model (Best Estimates)				
Stock Group	Steveston to Mission	Mission to Sawmill Cr.	Sawmill Cr. to Prince George	Terminal Area Catches 1	Total Catch
Early Stuart	248	10,849	10,639	590	22,326
Early Summers (Misc. stocks)	5,127	20,405	13,499	26	39,057
Nadina, Gates, Pitt	4,681	12,468	10,245	156	27,550
Chilko, Quesnel	16,861	32,839	27,749	19,760	97,209
Late Stuart, Stellako	5,282	19,606	19,016	9,292	53,196
Birkenhead	618	0	0	0	618
Weaver, Portage & Misc. Late Runs	2,704	5	32	0	2,741
Adams & Misc. Late S. Thompson	5,345	180	323	2,573	8,421
Total	40,866	96,352	81,503	32,397	251,118

1. Terminal Areas include the Thompson River, Chilcotin River, Nechako River and Stuart River.

	Differences (Best Estimates minus Run Reconstruction Model Estimates)				
Stock Group	Steveston to Mission	Mission to Sawmill Cr.	Sawmill Cr. to Prince George	Terminal Area Catches 1	% Difference
Early Stuart		8,838	8,864		80.3%
Early Summers (Misc. stocks)		4,191	2,520		17.2%
Nadina, Gates, Pitt		5,982	5,340		41.0%
Chilko, Quesnel		-19,938	-19,780		-40.9%
Late Stuart, Stellako		927	3,056		7.1%
Birkenhead					
Weaver, Portage & Misc. Late Runs					
Adams & Misc. Late S. Thompson					

1. Terminal Areas include the Thompson River, Chilcotin River, Nechako River and Stuart River.

Summary of Results: 1996-1999

The scale-based DFA stock assessments identified more Early Stuart sockeye, than the run reconstruction model in both 1997 (408,485 fish versus 384,822 fish) and in 1999 (22,326 fish versus 4,391 fish) (Figure 2). As was discussed previously, the likely cause of these elevated catches was the slow passage of Early Stuart sockeye through the fishery due to high Fraser River discharge levels. Increased vulnerability due to the prolonged migration, or possibly due to stress on the fish, appears to have resulted in much higher harvest rates than expected. In fact, the difference in 1997 would likely have been higher if the scale sampling coverage had been more complete.

The best estimate of Early Stuart catch and the run reconstruction estimate of catch were identical in 1996, when no scale data were available, and very similar in 1998 (14,572 fish versus 15,327 fish), when only a limited amount of scale data were available. It is possible that

	1996-R	1996-S	1997-R	1997-S	1998-R	1998-S	1999-R	1999-S
Early Stuart	2,576	2,576	384,822	408,485	15,327	14,572	4,391	22,326

	1996-R	1996-S	1997-R	1997-S	1998-R	1998-S	1999-R	1999-S
Early Summers (Misc)	22,753	34,987	8,387	15,339	49,217	55,787	32,346	39,057

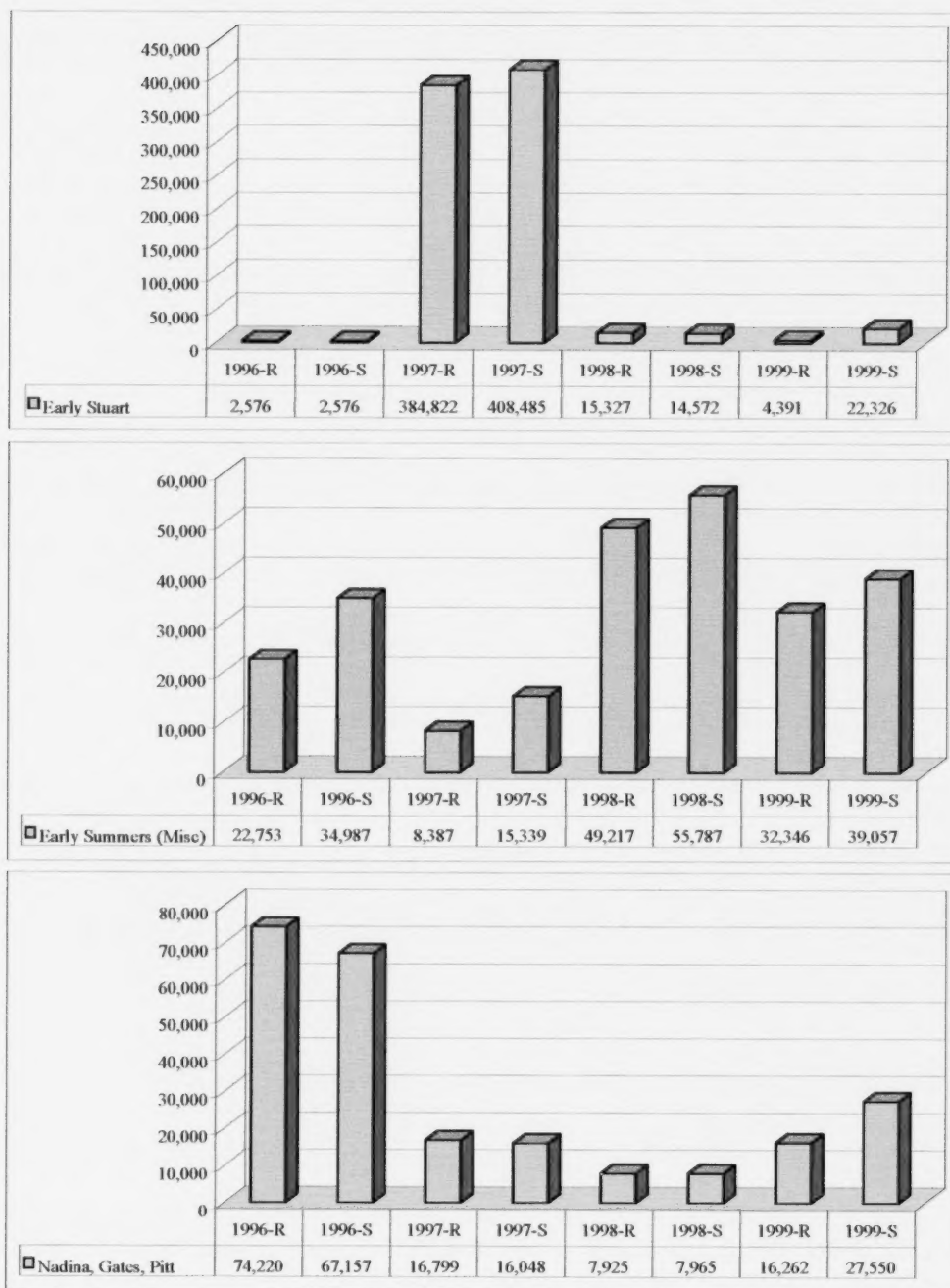|	1996-R	1996-S	1997-R	1997-S	1998-R	1998-S	1999-R	1999-S
Nadina, Gates, Pitt	74,220	67,157	16,799	16,048	7,925	7,965	16,262	27,550

Figure 2. Catch comparisons: Early Stuart and Early Summer stocks (Reconstructions "R" versus Scales "S"). Early Summer stocks include Early Summer (Miscellaneous stocks, including Fennell, Bowron, Scotch and Seymour) and Nadina/Gates/Pitt stock groups.

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significant differences between the two estimation methodologies would have been identified if additional scale samples had been available for analysis.

In the four years of the study, the scale-based DFA stock group estimates were on average higher for the Early Summer (miscellaneous stocks) stock group than was anticipated from the run reconstruction model. Figure 2 shows the annual estimate in each of the four years. In 1997 and 1999 the differences (15,339 fish versus 8,387 fish) and (39,057 fish versus 32,346 fish) were likely a result of the high discharge conditions that were present in the Fraser River during June and July. It is not clear whether the higher catch estimates in 1996 and 1998 (34,987 fish versus 22,753 fish) and (55,787 fish versus 49,217 fish) reflects higher vulnerability of this stock group to the First Nations fishery, random variation in the two estimation methods or bias associated with the estimation of small stock groups using DFA.

The Nadina/Gates stock group showed reasonably consistent estimates of catch in both the scale based DFA model and the run reconstruction model in 1996 (67,157 fish versus 74,220 fish), 1997 (16,048 fish versus 16,799 fish) and 1998 (7,965 fish versus 7,925 fish). The DFA model estimated substantially larger catch contributions of the Nadina/Gates stock group in 1999 (27,550 fish versus 16,262 fish) (Figure 2). The larger catch was likely caused by the high Fraser River water levels present during the upstream migration of the Nadina/Gates stock group. It is possible that the actual catch of the Nadina/Gates stock group was higher than estimated in 1997 (the other year of high Fraser River discharge), however, low proportions (< 5%) of the stock group limited the use of scale data to one or two weeks per catch area.

Generally, the DFA and the run reconstruction estimates of catch were similar for the Summer-run stock groups. In 1996 the two estimates were very close for the Chilko/Quesnel stock group (344,960 fish versus 340,317 fish) (Figure 3). The differences in catch estimates for the stock group were larger in the other three years, when the scale-based catch estimates were consistently lower than those predicted by run reconstruction: 1997 (455,514 fish versus 482,255 fish), 1998 (371,082 fish versus 399,195 fish) and 1999 (97,209 fish versus 136,927 fish). In each of the latter three years, environmental conditions existed in the Fraser River that may have influenced the migration behaviour of Fraser sockeye runs. Both 1997 and 1999 were high discharge years, while water temperatures were abnormally high in 1998. The affect of these adverse environmental conditions appears to have been a differential vulnerability to harvest of individual stock groups migrating during the period that the adverse conditions were present.

The catch estimates by the two estimators for the Late Stuart/Stellako stock group were similar in each of the four years of the study (Figure 3). The largest difference was in 1996, when the DFA model estimated almost 10,000 fewer fish than run reconstruction (214,348 fish versus 224,170 fish). In 1997, the scale-based estimate was slightly lower than the run reconstruction estimate (173,154 fish versus 176,283 fish). In both 1998 and 1999 the scale-based estimate was marginally higher than the run reconstruction estimate (130,891 fish versus 129,748 fish) and (53,196 fish versus 49,412 fish). The observed differences were within the range of random error expected from either estimation methodology. However, it is possible that the "true" differences would have been larger if better separation existed in the scale-based DFA models for the Early Stuart and Late Stuart/Stellako stock groups. It is possible that in the latter three years, when there was considerable timing overlap between the Early Stuart and Late Stuart/Stellako stock groups, that the Late Stuart/Stellako stock group was overestimated at the expense of the Early Stuart stock group.

	1996-R	1996-S	1997-R	1997-S	1998-R	1998-S	1999-R	1999-S
☐ Chilko, Quesnel	340,317	344,960	482,225	455,514	399,195	371,082	136,927	97,209

	1996-R	1996-S	1997-R	1997-S	1998-R	1998-S	1999-R	1999-S
☐ Late Stuart, Stellako	224,170	214,348	176,283	173,154	129,748	130,891	49,412	53,196

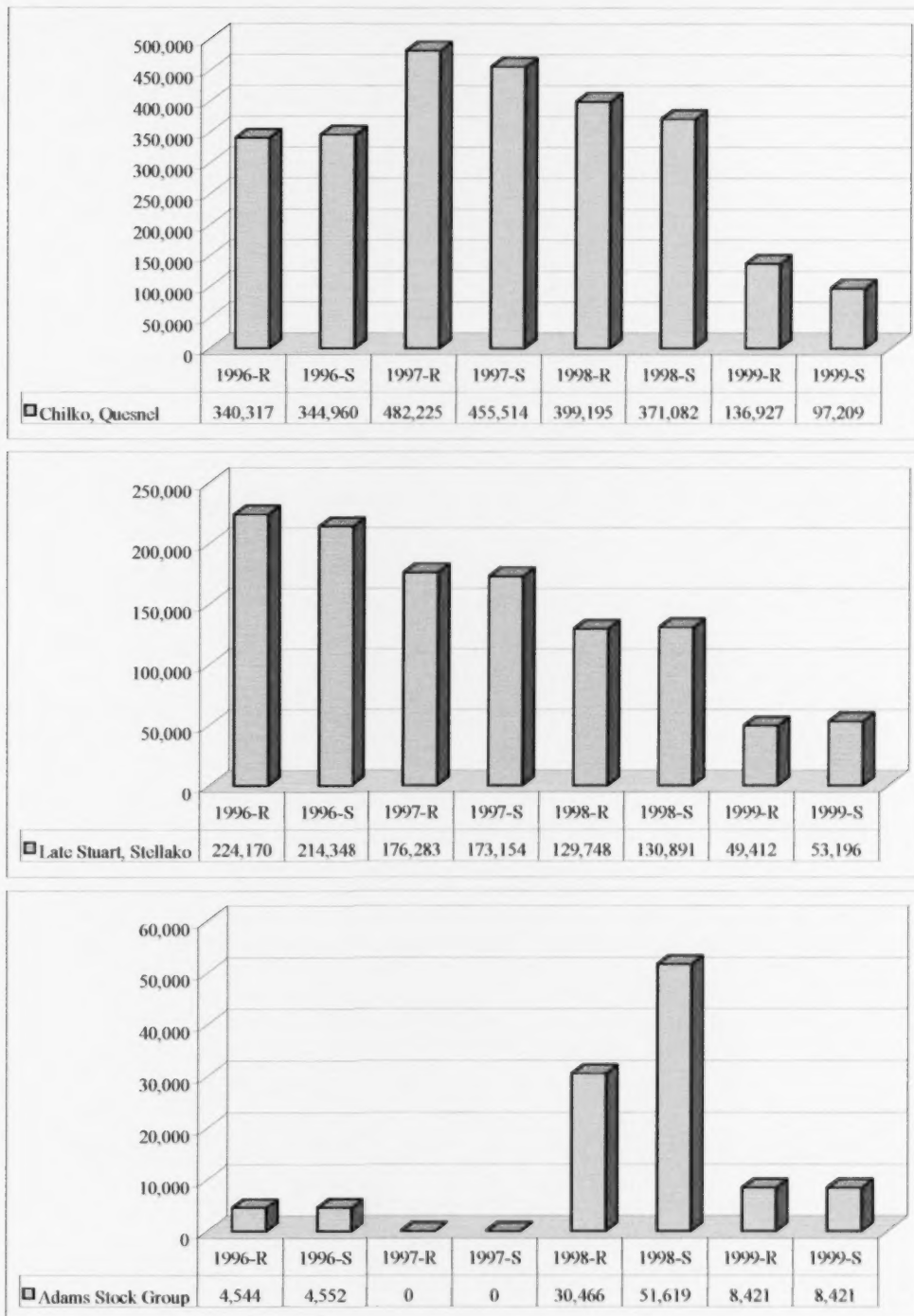|	1996-R	1996-S	1997-R	1997-S	1998-R	1998-S	1999-R	1999-S
☐ Adams Stock Group	4,544	4,552	0	0	30,466	51,619	8,421	8,421

Figure 3. Catch comparisons: Summer and Late-run stocks (Reconstructions "R" versus Scales "S").

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The only Late-run stock group for which scale-based estimates of catch were generated was the Adams/Lower Shuswap stock group in 1998 (Figure 3). The DFA model estimated much larger catches for the stock group than run reconstruction (51,619 fish versus 30,466 fish). In 1998 the Adams/Lower Shuswap stock group migrated into the Fraser River much earlier than normal, which possibly increased their vulnerability to First Nations fisheries, resulting in higher catches than projected by the run reconstruction model.

DISCUSSION

When the run reconstruction methodology was developed to indirectly apportion the First Nations catch into component stock groups, the annual catch in the First Nations fishery ranged from approximately 200,000 sockeye to 500,000 sockeye. For example, the average catch during the period from 1980 to 1989 was 419,000 fish (Table 14). During the 1990's the annual catches increased substantially, with an average catch of 739,000 sockeye from 1990 to 1999.

The biological and management need to accurately apportion the sockeye harvest into component stock groups has increased along with the catches in the First Nations fishery. Accurate stock production data rely on unbiased assessments of catch by stock group from all catch sources, including First Nations catches in the Fraser River. While run reconstruction methodologies may have sufficed when the catches were lower, the higher catches occurring in First Nations fisheries in recent years warrant a more accurate, direct estimation method, similar to that employed to estimate stock catches in commercial fisheries.

Comparisons for the 1989 to 1995 period showed that DFA and run reconstruction methodologies provided similar estimates of catch by stock group (Gable 1998). However, unusual in-river migration conditions in some recent years have increased the justification for a comprehensive First Nations scale sampling program to allow for the direct estimation of catch by stock group in key catch areas upstream of Mission. For example, the high Fraser River discharges from mid July to early August in 1997 and from June to early August in 1999 impeded sockeye passage through the Fraser Canyon, resulting in migration delays and mortality in some stocks. These occurrences cause violations in the stock availability and vulnerability assumptions in the run reconstruction model, and may cause biases in the assessment of catch by stock group in the in-river fisheries above Hope. This was evident in the elevated proportions of Early Stuart and Early Summer (miscellaneous stocks) sockeye identified in scale samples in both those years, relative to expected percentages generated by the run reconstruction model.

The main weakness in the sampling program to date it is that the sampling has sometimes been inconsistent, in regards to both time and area coverage. Particularly in 1996 and 1999, the objective of obtaining a minimum of 240 scales per week (by area) throughout the duration of the fishery was not achieved. In 1996, only 1,900 scales were obtained. Similarly, in 1999 only 1,369 scales were taken, and no samples were obtained from the majority of the designated sampling areas, in part due to high water and conservation closures. In contrast to these years was the more comprehensive temporal and spatial coverage of the sampling program in both 1997 and 1998, when 5,636 scales and 6,251 scales were obtained. It is important that the success of the program in these years be repeated on a consistent basis. It would also be beneficial to increase the sample sizes obtained from the sampling areas, and to consider expanding the number of sampling sites to increase the accuracy and precision of estimates generated by this stock identification program.

The designated sampling sites in the Fraser River First Nations fishery were located to provide sampling coverage in key catch areas, and to allow for the comparison of results

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generated from the run reconstruction model and from scale samples upstream and downstream of the confluences of specific Fraser River tributaries. Consideration should be given to expanding the number of sampling sites in future years, if catches continue to rise. The catch area between Steveston and Mission should be included in the expanded area coverage, in order to test the assumption that test fishery samples adequately represent First Nations catches in this area. In general, expanded scale sampling coverage would be expected to provide more accurate assessments of catch by stock group throughout the Fraser River, particularly in years of adverse environmental conditions when sockeye migration behavior is disrupted.

Table 14. Annual Fraser River First Nations sockeye catches (1980 to 1999).

Year	Total Catch	Average
1980	186,000	
1981	441,000	
1982	430,000	
1983	362,000	
1984	358,000	(1980-1989)
1985	424,000	419,000
1986	534,000	
1987	468,000	
1988	416,000	
1989	572,000	
1990	809,000	
1991	606,000	
1992	672,000	
1993	853,000	
1994	928,000	(1990-1999)
1995	892,000	758,000
1996	755,000	
1997	1,075,000	
1998	743,000	
1999	251,000	

Note. Catch data for years 1980 to 1991 from Macdonald (1992), catch data for 1992 from Larkin (1992), and catch data from 1993 to 1999 from Annual Reports of the Fraser River Panel to the Pacific Salmon Commission.

ACKNOWLEDGMENTS

REFERENCES

Gable, J. and S. Cox-Rogers. 1993. Stock identification of Fraser River sockeye salmon: methodology and management application. Pacific Salmon Comm. Tech. Rep. No.5: 36p.

Gable J. 1998. Sockeye stock composition estimates for Fraser River First Nations catches (1989 to 1995): A comparison between run reconstruction models and scale-based discriminant function models. Pacific Salmon Comm. Tech. Rep. No.9: 94p.

Larkin, P.A. 1992. Analysis of possible causes of the shortfall in sockeye spawners in the Fraser River. (A technical appendix to "Managing Salmon on the Fraser River", by Peter H. Pearse).

Macdonald, A.L. 1992. The Indian food fishery of the Fraser River: 1991 summary. Can. Data Rep. Fish. Aquat. Sci. 876: 86p.

Pacific Salmon Commission. 1999. Report of the Fraser River Panel to the Pacific Salmon Commission on the 1997 Fraser River sockeye and pink salmon fishing season. Vancouver, B.C., 47p.

Pacific Salmon Commission. 2000. Report of the Fraser River Panel to the Pacific Salmon Commission on the 1998 Fraser River sockeye salmon fishing season. Vancouver, B.C., 66p.

Pacific Salmon Commission. 2001. Report of the Fraser River Panel to the Pacific Salmon Commission on the 1999 Fraser River sockeye and pink salmon fishing season. Vancouver, B.C., 55p.

APPENDIX TABLES

Appendix Table 1. First Nations scale samples (1996).

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1996	Chilliwack	Mission to Hope	Aug 12-13	116	Scale data used	16,556

Note. In total the catch represented by scale samples = 16,556, or 21.5% of total catch for area. The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1996	Yale	Hope to Sawmill	Aug 3-4	222		4,116
1996	Yale	Hope to Sawmill	Aug 5-9 (interpolated)		Yale, dates = 8/4 & 8/10	7,859
1996	Yale	Hope to Sawmill	Aug 10-15	280		123,946
				502		135,921

Note. In total the catch represented by scale samples = 135,921, or 62.0% of total catch for area. The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1996	Lytton East	Sawmill to Lytton	Aug 5-6 (extrapolated)		Yale, dates = 8/3-4	13,464
1996	Lytton East	Sawmill to Lytton	Aug 8-11	69	Scale data used	15,175
1996	Lytton East	Sawmill to Lytton	Aug 12-17 (extrapolated)		Yale, dates = 8/10-15	10,278
				69		38,917

Note. In total the catch represented by scale samples = 38,917, or 37.2% of total catch for area. The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1996	Lytton West	Lytton to Lillooet	Aug 7-11	76	Scale data used	2,166
1996	Lytton West	Lytton to Lillooet	Aug 12-13 (extrapolated)		Lytton East, dates = 8/10-11	2,213
1996	Lytton West	Lytton to Lillooet	Aug 14-19 (extrapolated)		Yale, dates = 8/10-15	6,621
				76		11,000

Note. In total the catch represented by scale samples = 11,000, or 56.7% of total catch for area. The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1996	Bridge R	Lillooet to Kelly	Aug 4-10	327	Scale data used	1,855
1996	Bridge R	Lillooet to Kelly	Aug 11-17	398	Scale data used	7,744
1996	Bridge R	Lillooet to Kelly	Aug 18-24	331	Scale data used	7,686
1996	Bridge R	Lillooet to Kelly	Aug 25-26 (interpolated)		Bridge R, dates = 8/24 & 8/27	245
1996	Bridge R	Lillooet to Kelly	Aug 27-28	81	Scale data used	245
				1,137		17,775

Note. In total the catch represented by scale samples = 17,775, or 91.6% of total catch for area. The rest of the catch apportioned into stock groups using run reconstruction model.

Appendix Table 2. First Nations scale samples (1997).

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1997	Chilliwack	Mission to Hope	Jul 8-9	140	Scale data used	11,812
1997	Chilliwack	Mission to Hope	Jul 23-24	84	Scale data used	23,237
1997	Chilliwack	Mission to Hope	Aug 8-9 (interpolated)	Chilliwack, dates = 7/24 & 8/14	6,287
1997	Chilliwack	Mission to Hope	Aug 14-16	52	Scale data used	21,602
1997	Chilliwack	Mission to Hope	Aug 20-22	53	Scale data used	28,214
				329		91,152

Note. In total the catch represented by scale samples = 91,152, or 87.7% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1997	Yale	Hope to Sawmill	Aug 8-9 (extrapolated)	Chilliwack, dates = 8/7-8	13,088
1997	Yale	Hope to Sawmill	Aug 14-16	209	Scale data used	39,227
1997	Yale	Hope to Sawmill	Aug 20-22	212	Scale data used	24,555
1997	Yale	Hope to Sawmill	Aug 29-30	134	Scale data used	31,829
1997	Yale	Hope to Sawmill	Sep 1-2	204	Scale data used	16,246
				759		124,945

Note. In total the catch represented by scale samples = 124,945, or 41.7% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1997	Lytton East	Sawmill to Lytton	Jul 16-20	88	Scale data used	18,331
1997	Lytton East	Sawmill to Lytton	Jul 23-27	175	Scale data used	25,523
1997	Lytton East	Sawmill to Lytton	Aug 6-10	108	Scale data used	8,165
1997	Lytton East	Sawmill to Lytton	Aug-11 (interpolated)	Lytton E, dates = 8/10 & 8/12	2,294
1997	Lytton East	Sawmill to Lytton	Aug 12-15	65	Scale data used	9,174
1997	Lytton East	Sawmill to Lytton	Aug 16-27 (interpolated)	Lytton E, dates = 8/15 & 8/28	23,093
1997	Lytton East	Sawmill to Lytton	Aug 28-29	54	Scale data used	3,558
1997	Lytton East	Sawmill to Lytton	Sep 10-14	86	Scale data used	5,100
				576		95,238

Note. In total the catch represented by scale samples = 95,238, or 74.3% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1997	Lytton West	Lytton to Lillooet	Jul 10-13	72	Scale data used	882
1997	Lytton West	Lytton to Lillooet	Jul 17-20	146	Scale data used	1,596
1997	Lytton West	Lytton to Lillooet	Jul 23-26	109	Scale data used	1,458
1997	Lytton West	Lytton to Lillooet	Jul-27 (interpolated)	Lytton W, dates = 7/26 & 7/28	364
1997	Lytton West	Lytton to Lillooet	Jul 28-30	91	Scale data used	1,819
1997	Lytton West	Lytton to Lillooet	Aug 7-10	67	Scale data used	9,457
1997	Lytton West	Lytton to Lillooet	Aug 11-17	61	Scale data used	2,795
1997	Lytton West	Lytton to Lillooet	Aug 18-24	83	Scale data used	4,519
1997	Lytton West	Lytton to Lillooet	Aug 25-31	202	Scale data used	6,078
				831		28,968

Note. In total the catch represented by scale samples = 28,968, or 94.7% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1997	Bridge R	Lillooet to Kelly	Jul 10-13	187	Scale data used	882
1997	Bridge R	Lillooet to Kelly	Jul 17-20	118	Scale data used	1,596
1997	Bridge R	Lillooet to Kelly	Jul 23-27	273	Scale data used	1,822
1997	Bridge R	Lillooet to Kelly	Jul 28-Aug 3	229	Scale data used	2,670
1997	Bridge R	Lillooet to Kelly	Aug 4-10	251	Scale data used	8,605
1997	Bridge R	Lillooet to Kelly	Aug 11-17	217	Scale data used	2,795
1997	Bridge R	Lillooet to Kelly	Aug 18-24	201	Scale data used	4,519
1997	Bridge R	Lillooet to Kelly	Aug 25-31	234	Scale data used	6,078
1997	Bridge R	Lillooet to Kelly	Sep 1-7	137	Scale data used	1,505
				1,847		30,472

Note. In total the catch represented by scale samples = 30,472, or 99.6% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1997	Sheep Cr	Deadman to Marguerite	Jul 21-27	312	Scale data used	15,518
1997	Sheep Cr	Deadman to Marguerite	Jul 28-Aug 3	481	Scale data used	15,108
1997	Sheep Cr	Deadman to Marguerite	Aug 4-10	153	Scale data used	9,256
1997	Sheep Cr	Deadman to Marguerite	Aug 11-16	148	Scale data used	4,139
1997	Sheep Cr	Deadman to Marguerite	Aug 19-24	123	Scale data used	3,151
1997	Sheep Cr	Deadman to Marguerite	Aug 25-31	77	Scale data used	2,474
				1,294		49,646

Note. In total the catch represented by scale samples = 49,646, or 93.4% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Appendix Table 3. First Nations scale samples (1998).

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1998	Chilliwack	Mission to Hope	Jul 29-Aug 1	135	Scale data used	13,238
1998	Chilliwack	Mission to Hope	Aug 4-5 (interpolated)		Chilliwack, dates = 8/1 & 8/6	6,942
1998	Chilliwack	Mission to Hope	Aug 6-7	187	Scale data used	5,566
1998	Chilliwack	Mission to Hope	Aug 12-15	267	Scale data used	20,651
1998	Chilliwack	Mission to Hope	Aug 18-22	179	Scale data used	17,399
1998	Chilliwack	Mission to Hope	Aug 25-28	181	Scale data used	19,231
				949		83,027

Note. In total the catch represented by scale samples = 83,027, or 94.3% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1998	Yale	Hope to Sawmill	Jul 29-Aug 1	249	Scale data used	34,002
1998	Yale	Hope to Sawmill	Aug 4-7	209	Scale data used	43,686
1998	Yale	Hope to Sawmill	Aug 12-15	211	Scale data used	23,365
1998	Yale	Hope to Sawmill	Aug 18-22	213	Scale data used	59,940
1998	Yale	Hope to Sawmill	Aug 25-28	236	Scale data used	25,209
				1,118		186,202

Note. In total the catch represented by scale samples = 186,202, or 99.1% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1998	Lytton East	Sawmill to Lytton	Aug 1-2	86	Scale data used	1,008
1998	Lytton East	Sawmill to Lytton	Aug 3-4 (interpolated)		Lytton E, dates = 8/2 & 8/5	5,602
1998	Lytton East	Sawmill to Lytton	Aug 5-7	106	Scale data used	8,403
1998	Lytton East	Sawmill to Lytton	Aug 8-10 (interpolated)		Lytton E, dates = 8/7 & 8/11	8,164
1998	Lytton East	Sawmill to Lytton	Aug 11-16	69	Scale data used	15,382
1998	Lytton East	Sawmill to Lytton	Aug 17-21	103	Scale data used	10,559
1998	Lytton East	Sawmill to Lytton	Aug 22-23 (interpolated)		Lytton E, dates = 8/21 & 8/24	4,222
1998	Lytton East	Sawmill to Lytton	Aug 24-30	141	Scale data used	11,381
1998	Lytton East	Sawmill to Lytton	Aug 31-Sep 5	219	Scale data used	3,431
1998	Lytton East	Sawmill to Lytton	Sep-06 (interpolated)		Lytton E, dates = 9/5 & 9/7	571
1998	Lytton East	Sawmill to Lytton	Sep 7-10	191	Scale data used	796
				915		69,519

Note. In total the catch represented by scale samples = 69,519, or 90.6% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1998	Lytton West	Lytton to Lillooet	Jul 31-Aug 2	56	Scale data used	502
1998	Lytton West	Lytton to Lillooet	Aug 3-4 (interpolated)		Lytton W, dates = 7/26 & 7/28	2,428
1998	Lytton West	Lytton to Lillooet	Aug 5-9	75	Scale data used	6,068
1998	Lytton West	Lytton to Lillooet	Aug 10-16	186	Scale data used	2,903
1998	Lytton West	Lytton to Lillooet	Aug 17-21	87	Scale data used	3,005
				404		14,906

Note. In total the catch represented by scale samples = 14,906, or 59.7% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1998	Bridge R	Lillooet to Kelly	Jul 27-Aug 2	514	Scale data used	1,172
1998	Bridge R	Lillooet to Kelly	Aug 3-9	798	Scale data used	8,496
1998	Bridge R	Lillooet to Kelly	Aug 10-16	406	Scale data used	2,903
1998	Bridge R	Lillooet to Kelly	Aug 17-23	253	Scale data used	4,206
1998	Bridge R	Lillooet to Kelly	Aug 24-30	200	Scale data used	6,716
1998	Bridge R	Lillooet to Kelly	Aug 31-Sep 6	56	Scale data used	1,200
1998	Bridge R	Lillooet to Kelly	Sep 7-13	76	Scale data used	147
				2,303		24,840

Note. In total the catch represented by scale samples = 24,840, or 99.4% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1998	Sheep Cr	Deadman to Marguerite	Jul 27-Aug 2	144	Scale data used	1,680
1998	Sheep Cr	Deadman to Marguerite	Aug 3-9	216	Scale data used	1,544
1998	Sheep Cr	Deadman to Marguerite	Aug 10-16	100	Scale data used	1,502
1998	Sheep Cr	Deadman to Marguerite	Aug 17-23	52	Scale data used	1,861
1998	Sheep Cr	Deadman to Marguerite	Aug 24-30	50	Scale data used	789
				562		7,376

Note. In total the catch represented by scale samples = 7,376, or 91.3% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Appendix Table 4. First Nations scale samples (1999).

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1999	Chilliwack	Mission to Hope	Aug 7-8	65	Scale data used	5,589

Note. In total the catch represented by scale samples = 5,589, or 21.0% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1999	Yale	Hope to Sawmill	Jul 26-31	280	Scale data used	25,255
1999	Yale	Hope to Sawmill	Aug 1-4 (interpolated)		Yale, dates = 7/31 & 8/5	11,391
1999	Yale	Hope to Sawmill	Aug 5-7	220	Scale data used	25,629
1999	Yale	Hope to Sawmill	Aug 8-10	97	Scale data used	6,171
				597		68,446

Note. In total the catch represented by scale samples = 68,446, or 96.1% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1999	Lytton East	Sawmill to Lytton	Jul 28-Aug 2 (extrapolated)		Yale, dates = 7/26-31	7,494
1999	Lytton East	Sawmill to Lytton	Aug 3-6 (extrapolated)		Yale, dates = 8/1-4	27,806
1999	Lytton East	Sawmill to Lytton	Aug 7-9 (extrapolated)		Yale, dates = 8/5-7	9,268
1999	Lytton East	Sawmill to Lytton	Aug 10-12 (extrapolated)		Yale, dates = 8/8-10	11,151
						55,719

Note. In total the catch represented by scale samples = 55,719, or 91.3% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1999	Lytton West	Lytton to Lillooet	Jul 30-Aug 4 (extrapolated)		Yale, dates = 7/26-31	692
1999	Lytton West	Lytton to Lillooet	Aug 5-8 (extrapolated)		Yale, dates = 8/1-4	1,064
1999	Lytton West	Lytton to Lillooet	Aug 9-11 (extrapolated)		Yale, dates = 8/5-7	1,411
1999	Lytton West	Lytton to Lillooet	Aug 12-14 (extrapolated)		Yale, dates = 8/8-10	1,385
						4,552

Note. In total the catch represented by scale samples = 4,552, or 77.3% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1999	Bridge R	Lillooet to Kelly	Aug 3-9	188	Scale data used	1,419
1999	Bridge R	Lillooet to Kelly	Aug 10-16	222	Scale data used	2,923
1999	Bridge R	Lillooet to Kelly	Aug-17 (interpolated)		Bridge R, dates = 8/16 & 8/18	127
1999	Bridge R	Lillooet to Kelly	Aug 18-22	297	Scale data used	633
				707		5,102

Note. In total the catch represented by scale samples = 5,102, or 86.6% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.

Year	Sample Site	Catch Area	Date	Scale Data Sample Size	Sample Details	Catch Corresponding To Sample
1999	Sheep Cr	Deadman to Marguerite	Aug 5-6	58	Scale data used	266

Note. In total the catch represented by scale samples = 266, or 3.1% of total catch for area.
The rest of the catch apportioned into stock groups using run reconstruction model.